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VERBAL AND NONVERBAL LEARNING IN CHILDREN INCLUDING THOSE
WITH HEARING LOSSES, PART II.
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THIS STUDY WAS THE SECOND PART OF AN INVESTIGATION OF VERBAL LEARNING IN CHILDREN, THE FIRST PART BEING CONCERNED WITH THE EFFECTS OF AUDITORY, VISUAL, AND COMBINED AUDIOVISUAL PRESENTATIONS UPON THE LEARNING OF VARIOUS KINDS OF MATERIALS IN A PAIRED-ASSOCIATE PARADIGM. THIS PORTION OF THE STUDY INVOLVED AN EXTENSIVE INVESTIGATION OF THE PARAMETERS OF THE EARLIER FINDINGS. THE PURPOSE OF THIS PORTION OF THE STUDY WAS TO EXPLORE THE VARIABLES THAT DETERMINE THE SELECTION OF A SINGLE MODALITY FROM A BIMODAL PRESENTATION. AS A RESULT, THE DIMENSIONS OF MEANINGFULNESS, THE RELATIONSHIP OF MEANINGFULNESS TO THE STUDENT'S CHOICE OF THE AUDIO OR THE VISUAL MODE OF PRESENTATION, AND THE EFFECTS OF THE FINDINGS ON THE EDUCATION AND TRAINING OF NORMAL AND HARD-OF-HEARING CHILDREN WERE INVESTIGATED UNDER CONDITIONS OF A RECALL, PAIRED-ASSOCIATE PARADIGM AND THROUGH ESTIMATIONS OF ASSOCIATION VALUES FOR A LARGE PORTION OF THE MATERIALS USED IN PAIRED-ASSOCIATE TASKS. THE AUTHOR CONCLUDED THAT THE CONCEPT OF MEANINGFULNESS IS MORE COMPLEX THAN HAD BEEN ASSUMED AND THAT SUCH PARAMETERS AS "THE ABILITY TO PRONOUNCE" AND "DISCRIMINABILITY" AFFECT LEARNING IN CHILDREN IN THE SAME MANNER AS THEY DO IN ADULTS. MOREOVER, MEANINGFULNESS IS NOT TO BE VIEWED IN AN ABSOLUTE FASHION BUT IS ALWAYS RELATIVE TO THE CONTEXT IN WHICH THE MATERIAL TO BE LEARNED IS PLACED. TO THE EXTENT THAT THE SAME MATERIALS PRODUCED DIFFERENT LEVELS OF PERFORMANCE IN DIFFERENT SITUATIONS, MEANING CAN BE SAID TO BE RELATIVE. THE FIRST PART OF THIS PROJECT IS ED 001 264. (GD)

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VERBAL AND NONVERBAL LEARNING IN CHILDREN INCLUDING THOSE WITH HEARING LOSSES, PART II

Project No. 2207 (5-0661)
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INTRODUCTION

The present study grew out of two previous investigations by the author of verbal learning in both normal and hearing-handicapped children. The initial study (Cooperative Research Project #289 entitled Verbal Learning Among Children with Reduced Hearing Acuity) was concerned primarily with evaluating the effectiveness of a combined audio-visual presentation of material in teaching hard-of-hearing children. Normal-hearing children were also tested to provide a basis for comparison. The results suggested that a combined audio-visual presentation benefited neither normal-hearing children nor those with varying degrees of hearing loss.

These findings were surprising and had implications for teaching in general. However, without further evidence, they were restricted to the materials and paradigm used in the project. In order to more fully evaluate the generality of the findings, an extensive investigation of the parameters involved was designed. Because of the depth and breadth of the area under study, two projects were conducted.

Part I (Cooperative Research Project #1001 entitled Verbal and Nonverbal Learning in Children Including Those with Hearing Losses) explored methodically the effects of auditory, visual, and combined audio-visual modes of presentation upon the learning of three classes of materials: meaningful-verbal, i.e., words; nonmeaningful-verbal, i.e., trigrams of the form "consonant-vowel-consonant"; and nonmeaningful-nonverbal material, i.e., sounds or symbols without readily available labels. Normal-hearing children ranging from preschool through the twelfth grade were tested to determine the role that age plays in performance. Children in residential schools for the deaf were tested with the same materials and procedures to determine the changes in performance as a function of the loss of efficiency in one modality.

The results of Part I verified and extended the findings of the initial study. A combined presentation was never superior to the better of the two single modality presentations regardless of age, material, or hearing ability. The findings also suggested that the normal child selects the single modality which is most meaningful when faced with a bimodal task. In the same way, the deaf child might be viewed as selecting the more meaningful single modality, but in his case the visual channel is always more meaningful. Again we were left with results which, if generalizable, would imply a reexamination of the teaching methods used with both normal and hard-of-hearing children.

The present study constitutes Part II of the investigation. Its purposes were to explore the variables which determine this "unimodal" response in the child. The dimensions of meaningfulness came under scrutiny since these are involved in the choice of modality. Attempts were made to determine whether the preferred modality is solely a function of material in normal-hearing children. The superiority of a combined presentation has not been demonstrated in experiments where either single channel provides enough information to master the task. However, tasks where the combined approach is necessary, i.e., where the unique stimulus is obtained only by integrating information from the auditory and visual channels, have not been studied. These situations are more representative of those occurring normally and the variables determining the effectiveness of such conditions were examined. With the results from Parts I and II available, the roles of modality of presentation and meaningfulness of material can be evaluated more precisely. The importance of these variables in the learning process of both normal and hearing-handicapped children is obvious.

OBJECTIVES

The major goals of this project are: (1) to define "meaningfulness" or the dimensions of meaningfulness in children, (2) to study the relationship of meaningfulness to sensory channels of presentation, and (3) to relate the findings to the education and training of normal and hard-of-hearing children.

Answers to the following types of questions were expected from analyses of the data:

a. How important is the discriminability of the items in a learning task? Is learning faster with greater discriminability?

b. Does similarity of meaning or similarity of symbolization cause more interference? Can the effect of similarity in one channel be overcome by dissimilarity in the other sensory channel?

c. Is pronounceableness an important item in verbal learning? Assuming equal associative values, will pronounceable material be easier to learn than nonverbal material? What is the effect of subvocal pronunciation on learning?

d. Given a complex learning task, will the subject do better if he learns components of the task first or if he is faced with the entire task right from the start?

e. How flexible is the phenomenon of modality preference? Does bimodal attention occur if the situation demands it?

f. Do subjects with moderate hearing losses perform more like normal or like "deaf" subjects in a bimodal situation? That is, do they respond to meaningfulness or to modality?

RELATED RESEARCH

The present study is the second part of an investigation of verbal learning in children, Part I being Cooperative Research Project #1001 entitled *Verbal and Nonverbal Learning in Children Including Those with Hearing Losses*. The first part was itself an elaboration of Cooperative Research Project #289 and was concerned with the effects of auditory, visual, and combined audio-visual presentations upon the learning of various kinds of materials in a paired-associate paradigm. A review of the findings of Part I shows that children usually attend to only one modality whenever two are used; i.e., the combined presentation was never superior to the better of the two single modality presentations. This is true over the wide age range of children tested. It also seemed that the modality receiving the attention was that containing the more meaningful material. These same generalizations hold for hearing-handicapped children as well, since the visual modality is always the most meaningful by definition for such children.

Two important factors demanded further investigation: (1) the parameters of meaningfulness for children, and (2) the parameters of unimodal attention to bimodal stimulation. These form the core of Part II, the present study.

Meaningfulness has already been examined in adults with results that are far from satisfactory in providing a good, concise, objective definition of the concept. However, while we still do not know what meaningfulness is, there is good agreement as to how to measure it. Underwood and Schulz (1960) examined the many ways in which meaningfulness has been scaled and concluded, from the high intercorrelations, that all are tapping the same underlying dimension (presumably meaningfulness).

Previously, we had defined our materials as meaningful in terms of adult scale values. The performance of children varied as predicted with changes in meaningfulness assuring us that the same concept is valid for children. However, it was necessary to examine more closely the meaningfulness of our items in terms of children's norms in order to be precise in our discussions of the effects of meaningfulness upon learning.

Of importance also in assessing the meaningfulness of verbal material for children was the examination of differences with deaf children. Differences might be expected from the fact that the two groups of children acquire language in different ways. The normal-hearing child first learns language aurally, then visually; while the deaf child learns the same language visually, and then aurally, in most cases. Several studies have shown that transfer from an auditory to a visual modality is better than the opposite. Gaeth (1960; 1963) and Pinsleur and Bankowski (1961) report a decrement in learning when switching from a visual to an auditory presentation. The extent to which the two classes of children scale the same verbal material differently should provide insight into the concept of meaningfulness. It would also aid in determining the most efficient approaches to use with the deaf in a learning situation.

The second major problem to be investigated, that of unimodal attention to a bimodal stimulus, has received much attention from theorists who are concerned with the capacity of man to handle incoming signals. Many have concluded that man is intrinsically unable to process more than one signal, or "bit" of information, at a time. This concept has been variously described as a single-channel system (Broadbent, 1956), a psychological refractory period (Davis, 1959), or a central decision process (Adams, 1962). While the labels may differ, the basic characteristics of the concept remain the same. It is hypothesized that all incoming signals, regardless of modality, arrive at a common central area for processing, and that this area can handle only one signal at a time. Consequently, signals arriving simultaneously from two different sense organs cannot be processed together. The information in one channel must be ignored or delayed until the processing mechanism is cleared. From this point of view, one would infer that man can never respond to a bimodal situation in other than a unimodal fashion.

The amount of information which can be processed at one time is undefined. Much of the experimental evidence offered in support of the single-channel theory is derived from studies employing clicks and flashes as stimuli. It would seem, however, that a unit of information is not fixed. Halliday, Kerr, and Elithorn (1960) showed that flashes which are nearly simultaneous can be "grouped" for processing, suggesting that the decision process is under some higher central control. More simply expressed, there may be another brain area which tells the processing area what size the unit of information is to be before processing commences.

Speech materials have also been used in investigating the single-channel hypothesis. Mowbray (1964) found that different words presented simultaneously to the two ears could not both be recognized. His subjects performed an auditory shadowing task, i.e., repeating the word after hearing it, with material presented to one ear. Randomly, a target word was presented to the other ear in a different voice. Results showed that the target word disrupts performance on auditory shadowing even if it was not recalled correctly. In a previous study employing the same auditory shadowing task but using visual target words, interference was not found. Mowbray initially interpreted this as contrary to the single-channel theory but upon reconsideration, he felt that the task was not relevant because the subjects may have rapidly alternated between the two modalities, gaining enough information from each to recognize the words.

This brings us to another dimension of response in a bimodal situation, modality preference. Results in Part I suggested that the more meaningful modality is selected, with meaningfulness defined differently for normal-hearing and deaf children. Because of the design of the experiments in that project, meaningfulness and modality were confounded so that it is impossible from those data to determine whether there is a tendency to remain with one modality or whether attention can as efficiently be directed to the visual and auditory channels as the relative meaningfulness of these modalities vary. Broadbent and Gregory (1961) showed that information (digits) presented alternately to the eye and ear were recalled better by modality category than in order of presentation. Apparently, attention can be alternated to the two sense modalities under the conditions used by those investigators, but the material is integrated better by modality than by temporal sequence. Their study, however, did not involve simultaneous bisensory stimulation. Lordahl (1961) presented auditory and visual stimuli simultaneously and the subject had to attend to both to learn a concept. His findings show a strong tendency to attend only to the visual stimuli, ignoring the auditory modality. Hutton (1959), however, in teaching language in an aural rehabilitation situation found auditory stimuli gave about 50% more information than did visual, and that a combined presentation was better than the sum of the performances on the two single modality tasks.

Many of the phenomena of the real world must be apprehended both visually and auditorily to gain a total picture of the event. If the events are to be presented for learning, what is the most efficient manner of presentation -- should all the visual aspects be presented before any of the auditory elements are considered? Should elements in the two modalities be presented simultaneously, nearly simultaneously, or alternately? These are the kinds of questions which arise from an examination of the research related to the major problems of this study. Attempts will be made to gain answers to such questions. We recognize the fact that, although we have not been able to demonstrate the superiority of a combined audio-visual presentation, our results may be a function of the experimental design employed. The current project will directly examine these factors to provide a better description of the role of bisensory stimulation in verbal learning. Additional related research will be introduced in the sections concerned with the specific experiments conducted as a part of this project.

APPARATUS, TEST MATERIALS, SUBJECTS AND PROCEDURES

Two major types of experimentation were conducted. A majority of the data was collected under the conditions of a recall, paired-associate paradigm. The details of this type of investigation will be presented here. A second mode of research was used to obtain estimations of association value for a large portion of the materials used in paired-associate tasks. The detailed explanation of those materials and procedures will be found in a later chapter along with the results.

A. Apparatus

Presentation of materials in the context of the paired-associate paradigm involved auditory, visual, and audio-visual displays, as appropriate to the specific problem under investigation. Visual materials were recorded on film while auditory materials were recorded on magnetic tape. To this end, two sets of apparatus were employed. Initially, a system which was developed for Part I (Cooperative Research Project #1001) was used. The system included an Ampex, Model 601-2, two-channel tape recorder, an amplifier (either a McIntosh MC 30 or a Fisher 20-A), a Bell & Howell 750 automatic slide projector for 2 x 2 slides, a 50 x 50 screen, and an eight-inch extended-range speaker in an appropriate enclosure. Auditory material was recorded on one channel of the tape recorder. The second channel contained signals which controlled the operation of the slide projector. The system allowed precise and reliable synchronization of auditory and visual material. In the cases where an audio-visual task was to be compared to either the auditory component alone and/or the visual component alone, the channel to be eliminated was merely turned off without affecting the reproduction or timing of the desired material.

During the course of the project a second system became available. This was the Tel-n-See system manufactured by Baptista Film Mission. The functional components of the original system were replicated in a case roughly 12 x 18 x 24 inches. Instead of slides, a 35 mm film strip carried the visual material. The film strip permanently maintained the order of visual materials, thus eliminating a possible source of error in the use of slides. The time lag, during the changing of slides with the Bell & Howell projector, was eliminated in that changing frames with the film strip occurred instantaneously, for practical purposes. Certain limitations involving the reproduction quality of the audio system of the Tel-n-See required the continued use of the Ampex-McIntosh-speaker system for some auditory presentations. For language material, however, the Tel-n-See performed well. The system used in each experiment is identified.

At various times oscillators, noise generators, and filtering systems were used to generate specific experimental materials. The use and description of these are made in the report of the specific experiment.

B. Test Materials

While maintaining the categories of materials used in Part I, a wider range of specific items within each category was employed in this project. In the meaningful-verbal classification, both the items of Part I and previously unused words were employed. The number of nonmeaningful-verbal items was expanded to more than 100 in the investigation of their associability and the application of these data to the examination of meaningfulness. Additional nonmeaningful-nonverbal stimuli were generated for both expansion of Part I results and investigation of stimulus parameters relevant to performance. These additional materials were used in both auditory and visual presentations. In the interest of simplicity, the exact description of most items will be made in the report of the experiment in which they were used.

Since a large portion of the experimentation uses materials from Part I, the descriptions of those materials are reproduced here for convenience in reference.

1. Nonmeaningful-nonverbal. Six visual symbols were created by using the electronic templets available with the Leroy lettering sets. Each symbol was generated so that it had two components and so that it appeared to have low associative value to the experimenters. Furthermore, the six symbols had been presented, prior to final selection, to a college class with the instruction that the students in the class were to write down any label that they felt could be applied to the symbols and to put down any associations which they made to the symbols. The items selected produced only

very indirect associations, and none produced discrete labels. The six symbols used are shown in Table 1 in Section 6.

The auditory signals were produced by utilizing the audio-generating, switching, and modulating equipment available in the laboratory of the Department of Audiology. Specifically, the six noises were produced as follows:

a. A white noise, which was simply recorded from a Grason-Stadler Speech Audiometer, Model 162.

b. A 15 Hz square wave, produced by a Hewlett-Packard, Model 202A, Low Frequency Function Generator.

c. A 400 Hz tone produced by a General Radio Oscillator, Model 1374, with 5 Hz triangular modulation into a reactance tube added to the fixed oscillator.

d. An interrupted 500 Hz square wave with 30 msec "on-time" and 30 msec "off-time".

e. An interrupted 1000 Hz square wave with 18 msec "on-time" and 240 msec "off-time".

f. Alternating 250 and 500 Hz tones, with the 250 Hz tone on for 24 msec, a delay of 80 msec, the 500 Hz tone on for 90 msec, and a delay of 80 msec.

2. Nonmeaningful-verbal. Three-letter nonsense syllables were selected from Glaze's list (1928). Items were chosen that fell below the 10% level on his lists, that were reasonably pronounceable, and that contained a minimum of repetition of letters. The six syllables used were: DAQ, KEZ, JID, WOJ, ZEG, and WUB.

3. Meaningful-verbal. Three-letter monosyllabic nouns, which were assumed to be highly familiar to children three years of age or older, made up these stimulus items. They were: GUN, ICE, ARM, SKY, RUG, and CAT. In addition to high familiarity, the items were chosen because they had a minimum of repetition of letters.

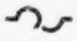
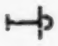
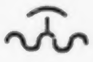
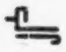
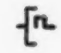
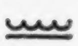
4. Stimulus labels. In the present report, the Arabic numeral subscripts, "1", "2", or "3", are used to refer to nonmeaningful-nonverbal, nonmeaningful-verbal, and meaningful-verbal material, respectively. The capital letters "A" or "V" are used to indicate the sensory channel through which the material was presented. Thus, A_1 represents nonmeaningful-nonverbal material presented auditorily; V_2 represents nonmeaningful-verbal material presented visually, and A_3V_3 indicates meaningful-verbal material presented bimodally.

5. Response items. The letters F, H, L, M, V, and X were used as the response items. Letters were chosen as response members rather than words or syllables for two reasons. First, the intent was to vary the meaningfulness and the sensory channel of presentation of the stimulus member while holding the response item as constant as possible. Letters of the alphabet appeared to be ideal in that they were highly familiar to the subjects and more likely to have constancy among the subjects than any particular set of simple words that might be chosen. Second, in a group learning situation it is necessary that the response members be written. Single-letter responses require a minimum of time and effort.

The six letters were selected on the basis of their visual and auditory characteristics rather than upon the frequency of their occurrence in written or spoken language. Since it was planned that the majority of the subjects to be used in the study would be at the fourth grade level or above, it was assumed that any letter of the alphabet would be adequately familiar to all subjects. It was arbitrarily decided to use only consonants and to select those that looked and sounded the least alike. To minimize visual confusion "M" was used, but not "N" or "W". Likewise, since "V" was used, letters such as "C", "D", or "Z" were not used because of their rhyming characteristics.

6. Stimulus-response pairings. The same stimulus and response pairings were used throughout the study. These pairings are given in Table 1. Additional materials and their responses are described in the specific experiments.

Table 1. Stimulus-response pairings from Part I.

Stimuli				Responses
A_1*	V_1	A_2 and V_2	A_3 and V_3	
a		WUB	CAT	H
b		KEZ	ICE	M
c		JID	ARM	V
d		DAQ	RUG	L
e		WOJ	SKY	X
f		ZEG	GUN	F

* The letters refer to the stimuli in the order described in Section 1.

C. Subjects

The subjects for this project were drawn from three groups. The Detroit Public School System and the school system of the Archdiocese of Detroit allowed experimentation to be conducted within their schools. The third group was formed from hearing-handicapped children enrolled in regular classes in the Metropolitan Detroit area. For the association value investigation, students at a residential school for the deaf were used in addition to students from the two school systems. The subjects from the school systems were tested in classroom sections. The hearing-handicapped were tested in groups of from two to five. The staff of the residential school conducted experimentation themselves.

The assignment of classroom sections to a particular experiment proceeded as follows: A school system representative and a representative of the research staff met to select the group of schools to be tested. Individual schools were then contacted and arrangements were made for a convenient testing date. Experimental conditions were randomly assigned to the classroom sections available in a particular school, with the restriction that each experimental condition encompass more than one school when more than one section was required. Care was taken to confirm, statistically, that no differences existed between different sections participating in a single experimental condition. When differences were found, the atypical section was omitted from the analysis and a replacement section tested and utilized in the analysis, again under the condition that it be compatible with like sections in the same condition. Significant differences were found very infrequently. In all cases, a section's atypical performance could be traced to some event, during the testing, unusual enough to disturb the group's attention. As has been implied, not only were records kept of the personnel assisting in each experimental session, but additionally, date, time of day, performance of equipment, and atypical environmental conditions were noted; e.g., excessive noise.

D. Procedure

As mentioned earlier, a recall, paired-associate paradigm was employed in the bulk of the experimentation. In general, a learning-test trial sequence was used; learning trial first, then test, then learning, et cetera, until 10 trials of each had been presented. A learning trial presented a stimulus and its unique response, then another, and so on until the full set of stimulus-response pairings had been presented. The following trial, a test trial, presented only the stimulus portion of the stimulus-response pair. Time was allowed between presentation of these stimuli for the subject to record the response, if he had learned it, in the booklets provided. Another learning trial was then presented during which the subject had another opportunity to learn the correct response to each of the stimuli. The order of the items in the learning and test trials was varied to prevent the subject from rotely learning a sequence of responses rather than the specific pairs.

Because of the demands of a particular set of materials, variations in the temporal sequences occurred. The three major temporal parameters, inter-stimulus (onset to onset) periods for learning trials, for test trials, and the inter-trial period will be specified in the individual experiments.

With the exception of the tests conducted on hearing-handicapped children, all testing was done in classroom sections. With the advent of the Tel-n-See apparatus, testing was done in the section's own classroom. In prior cases, availability of a testing room in the school and the relative bulkiness of the original testing system dictated that class sections move from their own room to one set aside for the experimental team. Care was taken to restrict testing periods to those times when the children would be most receptive. For example, testing was not done immediately prior to holidays.

The testing was conducted by a team of three, one for instructions, one for monitoring, and a third to operate equipment and aid in monitoring. While a general explanation of the purpose of the testing was made by the instructor, equipment was set up and answer booklets passed out. These provided a separate sheet for each test trial as well as a place for the recording of the child's name, age, grade, date of test, and school. Specific instructions as to the task followed the collection of the initial descriptive information. The instructor satisfied himself that instructions were understood before testing was initiated. As testing proceeded, the monitors were available to assure uniformity of testing conditions and to help children with any particular mechanical problem while the instructor maintained overall control of the session.

RESULTS PERTAINING TO
COOPERATIVE RESEARCH PROJECT #1001

At the conclusion of Cooperative Research Project #1001, Part I of this project, two important questions remained unanswered concerning the role that materials and procedure played in the results. In order to determine the generality of the findings, it was decided to investigate the effects of these two variables further to confirm that the effects attributed to variations in levels of meaningfulness and verbalness were not artifacts.

Experiment I is concerned with the nonmeaningful-nonverbal visual materials used in Part I of this project. It seeks to answer the question, "Were the results obtained with these materials typical or were they a function of the unique set of stimuli selected?"

Experiment II directs itself to the differential effect upon performance obtained by varying either the stimuli or the responses along the same dimension. Since all of the experiments in Part I had involved manipulation of stimuli, this point was of paramount importance to determine the restrictions that should be placed upon the interpretations of our findings. It is generally accepted that variations on the stimulus side produce less marked changes in performance than manipulations on the response side. To insure that the lesser effect of stimulus manipulation did not obscure differences which might have manifested themselves during the comparison of uni- and bimodal presentation, the materials used in Part I were reversed; i.e., response materials were used as stimuli and vice versa.

Experiment I

Learning of New Nonmeaningful-Nonverbal Material

ABSTRACT. Fourth- and fifth-grade students were tested in a paired-associate paradigm in which the stimulus item was a Greek letter and the response item was a single letter from the Roman alphabet. Results indicate that this material does not differ significantly from the nonmeaningful-nonverbal material used in Part I. The finding that nonmeaningful-nonverbal material produces higher levels of performance than nonmeaningful-verbal material (with visual presentation) is confirmed by this expansion of the nonmeaningful-nonverbal category of materials.

A. Introduction

At the inception of Part I it had been assumed that verbal materials would be more easily learned than nonverbal materials. The results from the visual presentation of two types of stimulus material are of interest here. The stimuli used were either nonmeaningful-verbal stimuli (three-letter nonsense syllables) or nonmeaningful-nonverbal material (modified electrical symbols). Comparing the performance by grade levels on these tasks, it was found that none of the differences between conditions was significant. However, in all cases but one (fourth grade) the nonmeaningful-nonverbal material was numerically superior in performance to the nonmeaningful-verbal. These results were based upon 502 subjects over five grades (4, 5, 6, 10, and 12).

In order to determine whether the comparison between nonmeaningful-verbal and nonmeaningful-nonverbal material is consistent using other materials in the same general class, the present study was conducted. Since some special characteristic of the modified electrical symbols may have led to the greater degree of learning found with the nonverbal material, it was felt that a second set of nonmeaningful-nonverbal material should be used in the same general testing situation.

For the present experiment Greek letters were selected as stimulus items for two reasons. First, it was felt that this set of material would not be familiar to fourth- and fifth-graders, thereby fulfilling one requirement. Secondly, it seemed to satisfy another qualification. One of the difficulties encountered in the generation of nonmeaningful-nonverbal material centered about the psychophysical question of discriminability among items of the set. It was felt that since the basis of any alphabetical system must be discriminability, the Greek alphabet provided stimuli free from previous encounter yet without complication from perceptual factors which might lead to intra-set confusion.

B. Experimental Procedures

1. Subjects. The subjects in this experiment were 136 children from the fourth and fifth grades of the Detroit Public School System.

2. Materials. Six Greek letters were used as stimulus items. The six response letters from the previous project were used as response items. The Greek letters, Delta (rotated 90 degrees clockwise), Zeta, Theta, Omega, Phi, and Psi, constituted the stimulus set. Omega, Phi, and Psi were in the capital or upper case form. The stimuli and their responses are presented in Table 1.1.

Table 1.1. Stimulus-response pairings for Experiment I.

Stimuli	∞	ζ	θ	Ω	Φ	Ψ
Responses	F	H	L	M	V	X

3. Procedure. The paired-associate paradigm was employed as the general experimental approach and the Ampex-Bell & Howell display system was used, consistent with the previous procedure. Inter-stimulus periods for both learning and test trials, as well as inter-trial periods, were held at those specified in Part I. Specifically, stimulus items were displayed for approximately 2.5 sec (allowing for projector operation) followed by 2.5 sec of response display during learning trials. Approximately 5.5 sec elapsed before the next pair was presented. The inter-trial period was approximately 11.5 sec. During a test trial only the stimulus was displayed for 2.5 sec followed by a 5.5 sec period for responding before the next stimulus item appeared.

C. Results and Discussion

The means and standard deviations of performance for the two experimental groups are presented in Table 1.2, along with selected data from Part I for electrical symbols and nonsense syllables. Learning curves for these conditions are given in Appendix A.

An inspection of Table 1.2 indicates that the superiority of nonmeaningful-nonverbal material is maintained with different stimulus items. Figure 1.1 (p. 25) illustrates the relationships among

Table 1.2. Means and standard deviations of the number of correct responses, by conditions and grades.

Conditions	Materials		Fourth Grade	Fifth Grade
V_1'	Greek Letters	$\bar{X}$	29.66	33.69
		SD	13.39	12.56
		N	68	68
V_1	Electrical Symbols	$\bar{X}$	19.80	34.93
		SD	9.66	14.33
		N	55	55
V_2	Nonsense Syllables	$\bar{X}$	23.53	25.56
		SD	11.81	12.44
		N	55	55

the data. The one case from Part I (fourth grade) where nonmeaningful-verbal material was superior to nonmeaningful-nonverbal was not replicated. The reversal in rank order of the two types of material (nonmeaningful-nonverbal greater than nonmeaningful-verbal) in the fourth grade is consistent with the results for the fifth, sixth, tenth, and twelfth grades in the previous project. It is believed, therefore, that the single comparison demonstrating a superiority of nonmeaningful-verbal material over nonmeaningful-nonverbal in the fourth grade is not typical.

D. Summary and Conclusions

This study was designed to verify the previous results with additional nonmeaningful-nonverbal visual materials. Findings from Part I (Cooperative Research Project #1001) indicated a general superiority of nonmeaningful-nonverbal material over nonmeaningful-verbal

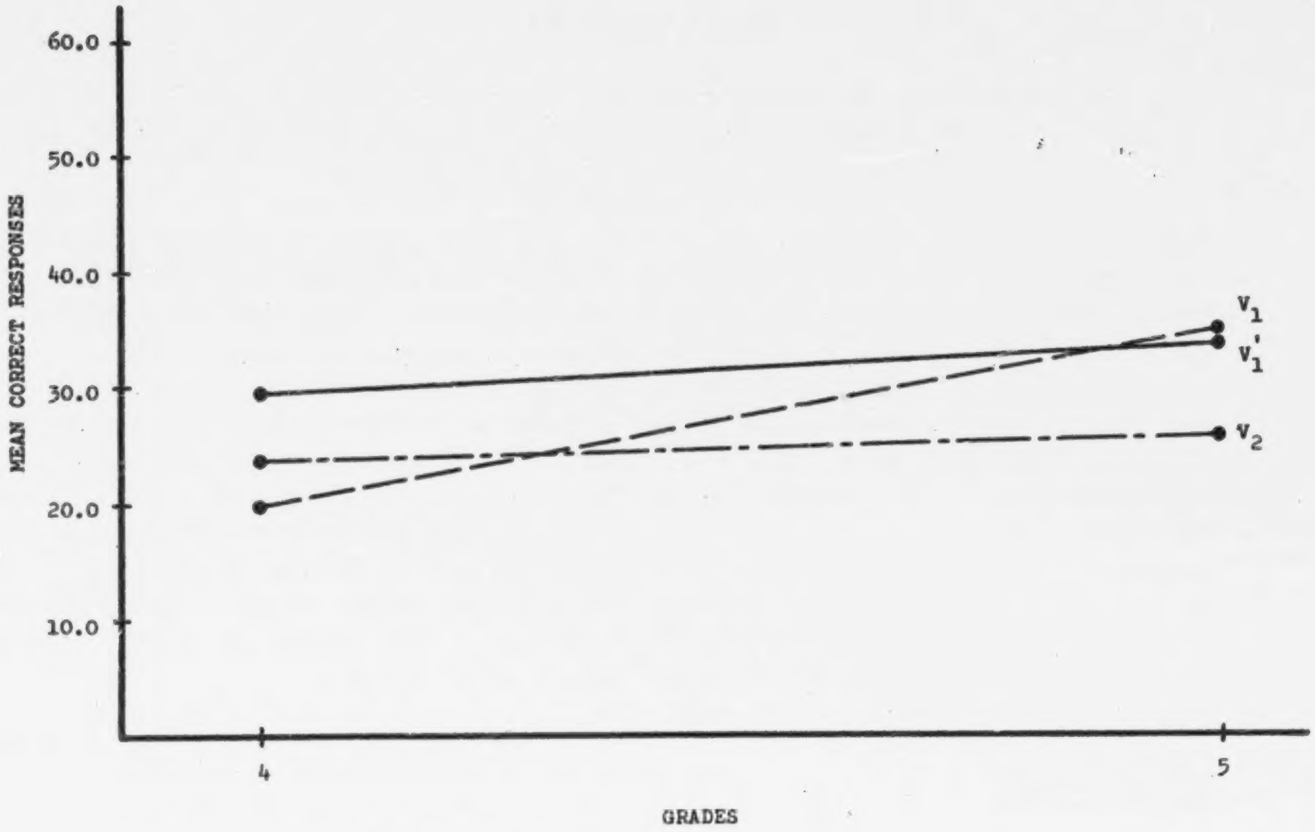


Fig. 1.1 Mean correct responses for Conditions V_1', V_1, and V_2; by grades.

material. The present results confirmed the finding, reversing the one previous exception found in the fourth grade.

It had been assumed at the outset of the previous project that verbalness formed a continuum, from nonverbal to verbal, which would be reflected as a parameter of learning performance. The exception found with visual nonmeaningful-nonverbal material was and remains a problem. It would seem that additional hypotheses concerning the classification of stimulation are needed.

Experiment II

The Relationship Between Bimodal and Unimodal Presentation with Material Variables Manipulated on the Response Side

ABSTRACT. A 2 x 3 factorial design was used to investigate the hypothesis that a bimodal presentation does not facilitate learning over the better of either of the two unimodal presentations of the same materials. A paired-associate task was used with two levels of material (nouns or CVCs) as responses and three modes of presentation (auditory, visual, or a combined audio-visual). Subjects were from the sixth grade. The results supported the hypothesis. No difference was found among the three modes of presentation employing nouns. For CVCs, the combined presentation was no different from the visual while both were significantly better than the auditory presentation. Performance with nouns was consistently better than with CVCs.

A. Introduction

A major conclusion from the two earlier Cooperative Research Projects is that a combined presentation is not better than the better of the two unimodal presentations. In those studies materials were varied on the stimulus side. The procedures used involved a paired-associate task in which the stimulus was from one of three classifications of materials: (1) nonmeaningful-nonverbal, (2) nonmeaningful-verbal, and (3) meaningful-verbal. Classification 3 refers to three-letter nouns; classification 2 to low association value nonsense syllables of the form CVC. Classification 1 used modified electrical symbols (for visual presentation) and sounds which were basically pure tones modified by modulation changes and interruptions. The materials were described previously in the section concerned with apparatus. The responses to these materials were single letters from the Roman alphabet. In a bimodal condition a single response letter was associated with two stimuli, one auditory and one visual. All combinations of material were made, i.e., A_1V_2, A_1V_3, et cetera, where the numbers refer to the classes of materials and the letters to the modality by which that material is presented. The finding holds when the auditory and visual components of the combined presentation are equivalent (as in the case where "GUN" is presented in each channel) or when the materials used in each channel of the combined presentation are different (as when "GUN" is presented visually and "KEZ" is presented auditorily).

It has been concluded that the manipulation of material variables on the stimulus side produces changes in performance which are less marked than those resulting from response side manipulation (Postman, 1962a; Underwood and Schulz, 1960). The purpose of this experiment was to extend the finding, no facilitation with bimodal stimulation, to the situation where material is varied on the response side. The complete matrix of conditions from Part I could not be replicated. There was no way for the subject to reproduce the nonmeaningful-nonverbal materials of Part I for a response. The bimodal conditions with different materials in each modality, e.g., auditory "KEZ" and visual "GUN", were also excluded in that the dual response required would not be comparable to "KEZ" presented both visually and auditorily. In the former case a six-letter response would be required versus a three-letter response in the latter. Thus, only six conditions were selected as shown in Table 2.1, as being suitable for testing the effects of response meaningfulness as it interacts with modality of presentation.

Table 2.1. Symbolic representation of the six conditions.

	V_2	V_3
A_2	A_2V_2	
A_3		A_3V_3

B. Experimental Procedures

1. Subjects. Sixth-grade students, from the Archdiocese of Detroit School System, served as subjects for the experiments. The pool of subjects for each condition was randomly reduced to 114 to simplify analysis.

2. Materials. The materials were classified as "2" (CVC trigrams) or "3" (three-letter nouns) in either the "A" or "V" modality. The exact materials are given in Table 2.2. The "2" material is different from that used in Part I. Changes were made to reduce intralist similarity. However, care was taken to insure that the association value was not altered. The mean association value (Archer, 1960) of the "2" material in Part I was 26.8 and that for the substituted materials used in this experiment, 22.2.

3. Procedure. Materials were presented by use of the Tel-n-See system. Auditory responses were pronounced a single time for each learning presentation. The visual items were presented for a

Table 2.2. Stimulus-response pairings for the two types of material used in the six conditions.

Stimuli	"2" Responses	"3" Responses
H	ZOT	CAT
M	GEC	ICE
Q	YUD	ARM
L	VAF	RUG
X	SIJ	SKY
P	KEB	GUN

duration of 2.5 sec. There were 10 learning trials alternated with 10 test trials. The time sequence involved in a learning trial was 2.5 sec of stimulus exposure (and/or one pronunciation) followed by 2.5 sec of response exposure (and/or one pronunciation). A 5 sec inter-pair interval was used. Inter-trial interval was 10 sec. On a test trial the stimulus was presented for 2.5 sec followed by 6 sec during which the subject recorded the response, before the presentation of the next stimulus item.

The subjects tested under an auditory condition were informed that an approximation of the spelling was all that was required. It was emphasized that spelling would not be graded. For the "2"-type material in the auditory condition, it was further explained to the subjects that they had two tasks to do. First, they would have to learn the S-R pairs as instructed, and, secondly, they would have to decide how to write the responses down. It was emphasized that the spelling was not critical, but the subjects were encouraged to retain whatever spelling they initially decided upon for each response to facilitate the scoring. Scoring of these items was handled by a person well-versed in phonetic transcription as well as in the purposes and procedures of the experiment itself. He initially presented the tape of "2" material to a group of speech correctionists and asked them to identify phonetically the responses presented therein. He determined from this both the quality of the tape itself and some indication of the variation ascribable to the syllables, since the judges were naive as far as CVCs are concerned.

With this kind of preliminary information at hand, he then looked over several booklets taken at random from children tested in this condition. In this way he established internal norms representing the ability of the subjects to assign orthographic symbols to the sounds. Using these criteria as guides, he then scored all the booklets for subjects receiving the auditory "2" condition as objectively as possible.

C. Results and Discussion

The mean correct responses and standard deviations for each condition are presented in Table 2.3. Figure 2.1 (p. 32) presents these data graphically. Learning curves for the six conditions appear in Appendix A.

A two-way analysis of variance was performed upon the data. As shown in the summary of the analysis, Table 2.4, both main effects

Table 2.3. Means and standard deviations of the number of correct responses by conditions.

Material		Auditory	Visual	Combined
"2"	$\bar{X}$	20.08	27.37	29.53
	SD	14.26	16.23	15.53
"3"	$\bar{X}$	44.09	45.50	45.66
	SD	12.85	11.71	12.02

were significant at $p < .01$ and the interaction was significant at $p < .05$. An analysis of the simple effects showed that, regardless of mode of presentation, nouns produced significantly higher performance than did CVCs in the same modality. Examining the effects of modality upon materials, it was found that there was no difference statistically in performance among the three noun conditions. In other words, the manner in which the nouns are presented makes no

Table 2.4. Summary of the analysis of variance for the two types of material and the six conditions.

Source	df	MS	F
Materials (Ma)	1	64517.0	33.53**
Modalities (Mo)	2	1923.5	9.99**
Ma. x Mo	2	855.5	4.44*
Within	678	192.4	

** $p < .01$.
* $p < .05$.

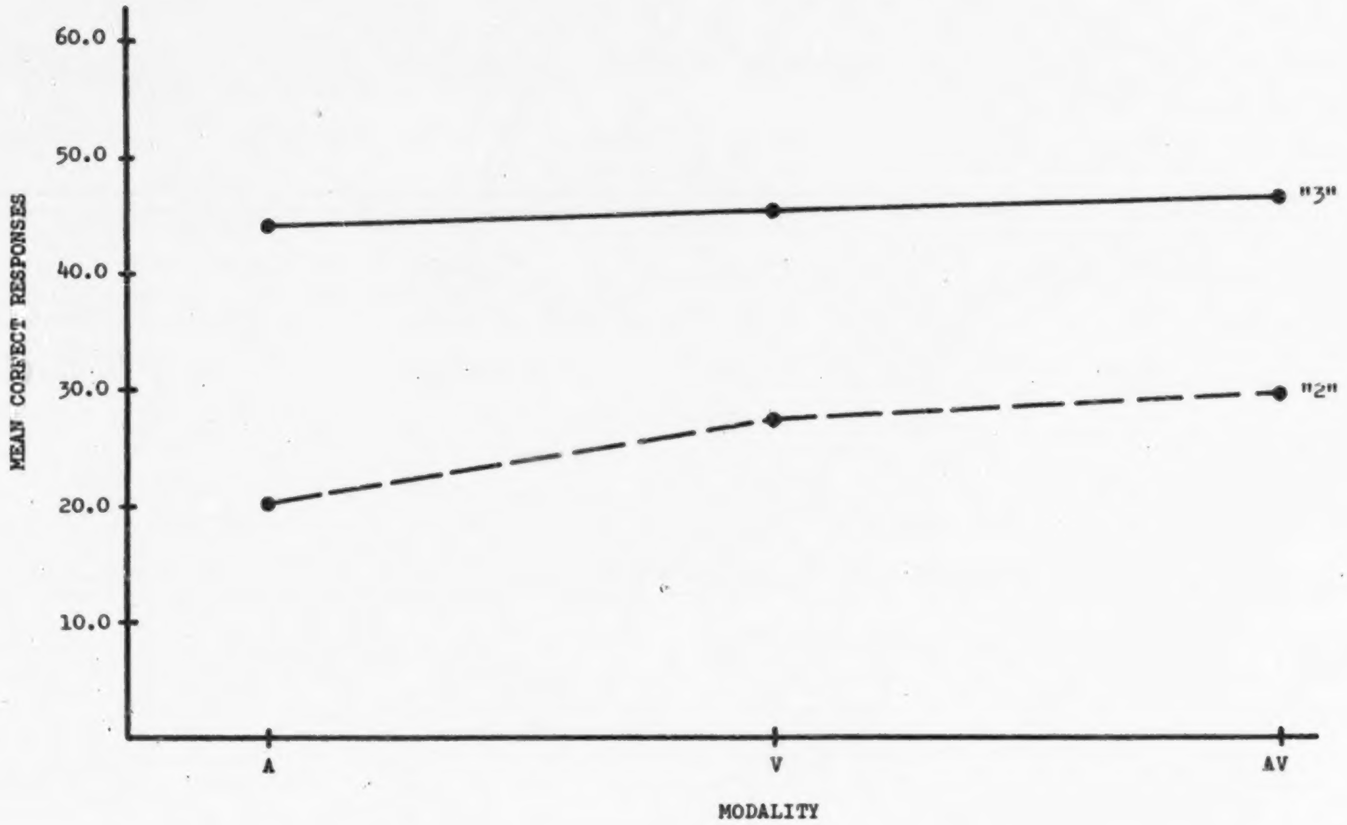


Fig. 2.1 Mean correct responses for materials; by modality of presentation.

difference in the level of performance attained in a fixed number of trials. When the CVC conditions were compared, a significant decrement in performance was noted with the auditory presentation while the visual and combined presentations did not differ from each other. Thus, the source of the significant interaction was due to the differential effect of the auditory presentation upon performance as a function of the materials, as illustrated in Figure 2.1.

It is not surprising that auditory presentation of the CVCs was low since there is no agreed-upon spelling, necessary for the written response, for the syllables heard in this condition as opposed to the highly stable relationship between the syllables on the noun tape and an accepted orthographic representation. Even with the great latitude provided by the scoring procedure as described previously, it is still obvious that the task differed in the two auditory conditions. With "2"-type material the subject had to both learn the appropriate responses and decide how to transcribe them, whereas with "3"-type material he had only to concern himself with the learning of the responses. Therefore, it is expected that the more complex task would result in poorer performance. In view of the major purpose of this study, the comparability of the auditory tasks is not a serious question.

D. Summary and Conclusions

This experiment was designed to test the hypothesis that a combined presentation of materials is never better than the better of the two unimodal presentations when the nature of the materials is manipulated on the response side. Using two levels of materials, it was found that the hypothesis was supported. Since it had been shown previously that the hypothesis is valid for material variations on the stimulus side, the evidence presented here adds further weight to the conclusion that subjects are not bimodal at any given time or task, but, at most, are selectively unimodal.

RESULTS PERTAINING TO MODALITY OF PRESENTATION

The research conducted in Part I of this investigation, as has been mentioned previously, indicated that the sensory modality by which materials are presented is a significant variable in learning. Not only is modality an important source of variation, but a significant interaction between modality and material was obtained. With nonmeaningful materials, performance in a visual presentation was better than when an auditory presentation was used, although these differences were not always significant. When a combined audio-visual presentation was employed, performance was comparable to that obtained with visual modality alone. With meaningful materials, on the other hand, differences attributable to modality of presentation are virtually eliminated. Again, however, the combined presentation did not improve performance over the better of the two unimodal presentations.

It was decided to examine this finding concerning the relationship between modality and meaningfulness and its effect upon performance in greater detail in the present project. The series of experiments discussed here constitute a more direct investigation of this facet of the learning problem.

Experiment III was made up of three parts, each of which examined in detail one aspect of what might be termed a manifestation of modality preference. The first part assumed that an index of preference for one mode of presentation, in a bimodal situation, might be obscured by the end of 10 learning and 10 test trials. The adopted paradigm proceeded to present unimodal test trials at various points during the course of learning (fourth, sixth, eighth, and tenth test trials). The proportion of correct auditory to correct visual responses was measured under the assumption that if the ratio changed during the course of learning then a preference might be inferred. The second part of Experiment III presented combined learning trials, as did the first. However, instead of measuring unimodal performance at only one point in the learning sequence, unimodal evaluations of performance were made on each test trial. The pattern of modality preferences throughout the learning task would then be available for examination. Part 3 of the experiment altered the task by using two different sets of material, one for audition and a different set for vision, each with their own responses. This contrasts with the first two parts of the experiment where, except for nonmeaningful-nonverbal materials, the same stimuli and responses were used for both modes of presentation. It was hypothesized that the use of unique but equivalent materials in the two modalities, with a simultaneous presentation, would cause the subject to shift to his preferred modality.

Experiment IV proceeded from Experiment III with important variations. As an approximation of the problems faced by individuals at the developmental level where auditory and visual language must be integrated, a bimodal presentation was utilized. The auditory and visual materials were different and had different responses. During a test trial both visual and auditory components were presented simultaneously. The pairing of visual and auditory items for simultaneous presentation was random so that both modalities had to be attended to. Two conditions were used. The first required immediate assimilation of the materials in the two modalities for a bimodal response. The second permitted independent learning of visual and auditory pairs, after which integration of the stimulus elements was required. The investigation was aimed at evaluating the efficiency of training methods: part learning with later integration versus integration from the outset.

Experiment V extended the investigation of integration of complex stimulus elements by making a single response (as opposed to the dual response of Experiment IV) contingent upon a bimodal stimulus complex. The effect of unimodal and bimodal presentation of the stimulus components was of major interest in this experiment.

Experiment VI examined the effect of modality in hearing-handicapped children. Specifically, a bimodal presentation was utilized initially, after which the visual component was omitted. In this manner, an evaluation could be made of the degree to which the learning of auditory material could be facilitated by additional visual material.

Experiment III

Modality Preference in Three Bimodal Tasks

ABSTRACT. Fourth-, fifth-, and sixth-grade students were used as subjects in three paired-associate experiments designed to explore modality preferences. The first unexpectedly introduced a unimodal test trial in an otherwise bimodal testing situation. The second routinely tested unimodally while the learning trials were all bimodal. The third utilized different stimuli and responses in each modality, with bimodal learning and test trials. The conclusion drawn from the series of experiments is that, when equated for difficulty and meaningfulness, the materials used failed to demonstrate modality preferences at a group level.

A. Introduction

This three-part experiment was begun as an extension of the problem of modality preference explored in Part I. There, differences in learning when paired-associate material was presented visually, auditorily, or combined audio-visually were inconsistent and varied as a function of the type of material, along meaningful and verbal dimensions. The possibility remained, however, that stable modality preferences were being obscured by the method of indexing performance, mean correct responses for 10 test trials. An eleventh trial, testing either auditory or visual material after 10 trials of a combined presentation, showed little preference which could not be attributed to factors such as similarity or list difficulty. This does not mean, however, that preferences might not operate at earlier points in the learning process.

Day and Beach (1950), summarizing the findings of numerous studies, concluded that the visual modality is more efficient than the auditory in the acquisition of meaningful material while the auditory is better for long-term retention. It is to the hypothesized modality preference that this series addresses itself. However, the long-term retention aspect of Day and Beach's hypothesis will not be investigated. Instead, the more general hypothesis, that modality preferences can be demonstrated, was investigated over a wider range of materials than the meaningful material of their original hypothesis.

Three types of materials were taken from Part I: nonmeaningful-nonverbal, nonmeaningful-verbal, and meaningful-verbal. Various techniques were employed in the investigation. The first experiment used a situation in which the subject could attend to either modality without debilitating performance. Nonmeaningful-nonverbal materials were used to maximize any difference. Into this context was injected an unexpected unimodal test trial. Should modality preference be operating, the sudden shift to unimodal presentation would bias the performance on the unimodal trial toward the preferred modality. The second experiment provided for unimodal evaluation of performance at each test trial and broadened the range of materials to include all three categories. The third experiment altered the task by requiring bimodal attention for complete mastery of it. The distribution of attention across the two modalities provided an alternate method of examining any preference.

B. Experiment 1

1. Introduction. This experiment was designed to explore the possibility that modality preference was being obscured by the use of a mean correct score after 10 trials. Using the procedure of experimentation in Part I, one modification was made. Here, unimodal tests of the bimodal task, A_1V_1, were made after 4, 6, 8, or 10 trials of bimodal presentation. This technique allowed inferences as to which modality was being attended to at the various stages of the learning task.

2. Experimental Procedures. Subjects in this study were 106 fourth-grade children enrolled in regular classes in the Detroit Public Schools.

Materials were taken from Part I of the project. The auditory stimuli consisted of six distinct noises, the A_1 material used previously. The six visual stimuli were modified electrical symbols, described as V_1 material. Detailed specification of these stimuli and their responses may be found in the earlier section describing apparatus.

The paired-associate procedure was used. A six-item paired-associate list was presented bimodally. Four experimental groups were used which differed as to the number of bimodal trials given before a unimodal test trial — 4, 6, 8, or 10 bimodal trials. Such groups are designated T4, T6, T8, and T10, respectively. The unimodal test consisted of a random order of the 12 stimuli from both modalities. All groups received the same random order of stimuli on the unimodal test trial.

The Ampex-Bell & Howell system was employed. During learning trials, each visual stimulus was projected on a screen for 2.5 sec, immediately followed by the appropriate visual response for 2.5 sec. The inter-pair interval was approximately 5 sec. These same time relationships held for the auditory material except that the auditory response letter was spoken and thus had a shorter duration. During the test trials, the stimuli were presented for 2.5 sec and the subjects had approximately 5.5 sec to write the response in a test booklet.

Instructions were standard, with no indication that a unimodal test would be given until just prior to that test trial. Subjects were then instructed that they would either see or hear the stimulus. During the test, subjects were given attentional cues ("look" or "listen") immediately preceding stimulus onset. It was felt that this procedure would better equate presentation times and, by ensuring attention to the stimulus, burden the subject only with response recall.

3. Results and Discussion. Table 3.1 presents the mean number of items correctly recalled during the unimodal test trial for each experimental group. Data are listed in Table 3.1 under "Auditory", "Visual", and "Both" headings, the latter referring to correct recall of a given response to both its auditory and visual stimulus.

Figure 3.1 (p. 42) presents these results graphically and indicates that all three categories, "Auditory", "Visual", and "Both", decrease in recall from T6 to T8, followed by an increase in Condition T10 for "Auditory" and "Both". These findings might be

Table 3.1. Mean number of correct responses for items recalled during the unimodal test for the four groups.

Modality	Group			
	T4	T6	T8	T10
Auditory	1.00	1.81	1.56	2.25
Visual	1.34	2.74	2.56	2.54
Both	.24	.85	.48	1.25
(N)	29	27	27	28

interpreted as indicating an initial preference for learning the visual material, followed by the learning of the auditory material. The mean number of visual items correctly recalled remains constant for T6, T8, and T10 implying that the subjects may learn the easier visual items first, and then attend to those auditory items which are easier than the rest of the visual list. The fact that the "Both" scores also rise suggests that the auditory stimuli learned tend to be those which are paired with the visual stimuli already learned.

It is not clear, from the present data, whether the trends observed are a function of modality per se or whether they reflect differences in difficulty among the items. The latter seems more tenable since visual learning leveled off early at about 2.5 items with the auditory stimuli being learned after that. This factor may enter into the general superiority of visual over auditory perform-

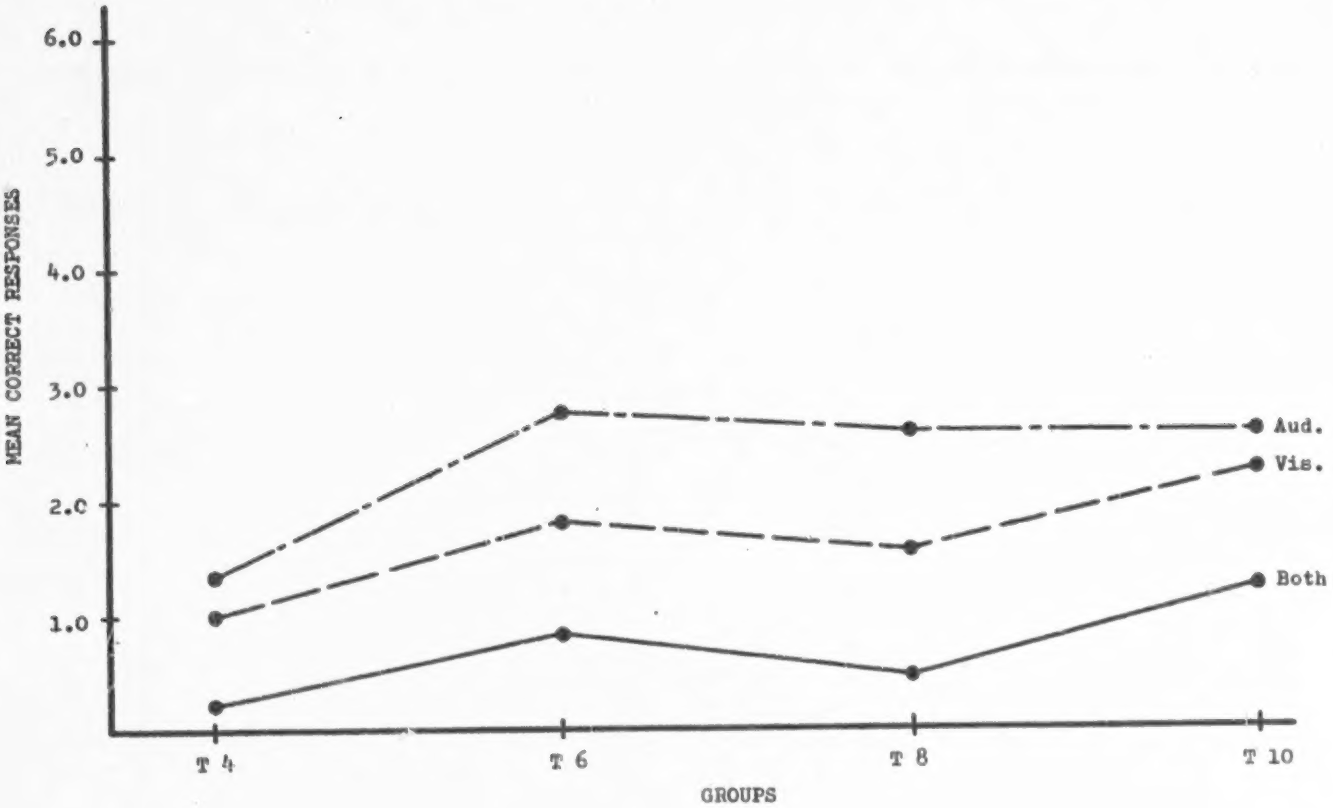


Fig. 3.1 Mean correct responses from unimodal test trial for modality; by groups.

ance reported in Part I using these same materials. The low "Both" score suggests that the items are not being learned simultaneously, but the rise in this curve indicates that they may be learned sequentially. That is, once the visual stimulus has been learned for a particular response, the auditory stimulus for that same response may be easier to learn than is another auditory stimulus-response pair.

C. Experiment 2

1. Introduction. The results from Experiment 1 were ambiguous. With the material and procedure used in that portion of the experiment, a preference for the visual modality was indicated. However, these findings were possibly confounded with item difficulty.

Consequently, the procedures were modified somewhat to form the present portion of the study and additional materials were also examined using these new procedures. All of the learning trials used a combined presentation, while all test trials were unimodal, presenting stimuli from each modality independently. It was felt that the use of this procedure would yield data relevant to the problem of modality preference.

2. Experimental Procedures. A total of 89 fourth-grade subjects from the Detroit Public Schools were used in this study.

The three sets of materials from Part I which comprised the conditions A_1V_1, A_2V_2, and A_3V_3 were used. The description of materials is given in the section concerned with apparatus.

A bimodal presentation was used for all 10 learning trials. All test trials were unimodal; i.e., the six visual stimuli were presented in a block independent of the six auditory stimuli. The subject was thus required to respond 12 times on each test trial. The modality of the first six test items was alternated; i.e., on the first test trial the auditory items followed the visual while on the second the visual followed the auditory, et cetera.

Standard instructions were modified to meet the requirements of the altered test trials. For the learning trials, stimuli were presented for approximately 2.5 sec followed by the response for a like period. The inter-pair interval was 5.5 sec. During a test trial the stimulus was presented for 2.5 sec with 5.5 sec allowed for the recording of the response. Before each test trial the subjects were told which modality would be tested first so as to focus attention on the appropriate dimension, thus eliminating possible errors due to improper attention. The Ampex-Bell & Howell system was employed to present the materials.

3. Results and Discussion. The mean correct responses by modality, standard deviations, and sample sizes for the three conditions are shown in Table 3.2. Learning curves for these data appear in Appendix A. The results of correlated *t* tests between the auditory and visual scores of each condition are also given in Table 3.2.

Table 3.2. Means and standard deviations of the number of correct responses in each modality by conditions.

Conditions		Trials 1-10		
		Auditory	Visual	$\underline{t}_{V-A}$
A_1V_1	$\overline{X}$	14.13	19.03	3.43**
	SD	7.30	10.45	
	N	31	31	
A_2V_2	$\overline{X}$	24.72	25.41	.70
	SD	12.37	11.80	
	N	32	32	
A_3V_3	$\overline{X}$	29.73	30.23	.66
	SD	15.74	16.32	
	N	26	26	

** $p < .01$.

Inspection of the table shows significant differences in the amount of learning of the auditory and visual components of A_1V_1 materials, with more visual items learned. This difference may be a function of the basic difference in the auditory and visual materials. In this condition, the subjects had to learn 12 different stimuli, six sounds and six figures. No index of list difficulty is available. However, these results are consistent with those obtained in Experiment 1 suggesting that the visual items are easier to learn.

Turning to the other materials in the other two conditions, no significant differences in the learning of A and V components were found. This may be taken as evidence for the equivalence of the auditory and visual representations of verbal materials.

D. Experiment 3

1. Introduction. This experiment was an outgrowth of the two earlier investigations in Experiment III. Those results suggested that modality preference, if it exists, is based upon differences between the auditory and visual materials in a bimodal task. This final experiment was designed to explore this proposition further. Thus, in this experiment each modality contained its own unique material, both stimuli and responses, but the two sets were equivalent in terms of difficulty or meaningfulness. A direct assessment of modality preference was obtained by presenting the two sets of material simultaneously and examining the responses.

2. Experimental Procedures. Subjects for this experiment consisted of 393 students from the fourth, fifth, and sixth grades of the Detroit Public Schools.

Twelve three-letter nouns and 12 single letters were used as stimuli and responses, respectively, to generate two sets of six S-R pairs. One set, to be used for visual presentation, was the "3"-type material from Part I. A second set of "3"-type items was generated to be used for auditory presentation. The two lists are given in Table 3.3. The materials presented visually are designated "GUN" and the auditory materials "EAR" for ease in reference.

Table 3.3. Stimulus-response pairings for auditory and visual materials.

Visual		Auditory	
Stimuli	Responses	Stimuli	Responses
GUN	F	EAR	B
CAT	H	OIL	Z
RUG	L	PEN	K
ICE	M	TOP	Y
ARM	V	WAX	Q
SKY	X	DOT	J

A combined condition, C, was used in which both the auditory and the visual material were presented simultaneously. To obtain temporal synchronization of the two modalities, the visual presentation consisted of the stimulus and response displayed side by side, unlike the other experiments of this project. The auditory presentation was temporally matched to the visual, with the response necessarily following the stimulus. The total duration of the stimulus and response was approximately 2 sec. The inter-pair interval was approximately 4 sec with an inter-trial interval of 10 sec. During the test trials the response was omitted and that time utilized by the subjects for writing down their responses. The Tel-n-See system was used.

Four control conditions were used in this experiment; all of them were unimodal presentations of the lists of materials given in Table 3.3. Not all grades were tested with every condition. Condition V presented only the visual ("GUN") items while Condition A presented the auditory ("EAR") items. In order to check the equivalence of materials across modalities, an additional two conditions presented the same materials but in the opposite modality. The "EAR" list was presented visually and "GUN" auditorily. In this latter visual condition ("EAR" list visually), the stimuli and responses were presented sequentially rather than simultaneously. In this way, the "EAR" list is procedurally equivalent to the V_3 ("GUN" list) as used in Part I of the investigation.

3. Results and Discussion. The mean correct performance, standard deviations, and sample sizes for the conditions are given in Table 3.4. In the combined condition (C) three indices of performance are reported. "A" represented the number of auditorily-presented items correct, "V", the number of correct visual items. Each of these had a maximum value of 60. The third index was the number of times both responses of a bimodal pair (A and V) were correct for a single presentation. This score is identified as "B". Learning curves for these conditions are given in Appendix A for

Table 3.4. Means and standard deviations of the number of correct responses, by conditions and grades.

Conds.		Fourth Grade			Fifth Grade			Sixth Grade		
		V	A	B	V	A	B	V	A	B
Exp.										
C	$\bar{X}$	7.0	4.7	.9	12.9	12.8	3.2	31.4	23.5	16.1
	SD	10.7	7.3	3.1	13.6	12.4	8.7	15.9	15.2	15.6
	N	70	70	70	29	29	29	99	99	99
Cont.										
V	$\bar{X}$				46.0					
	SD				14.5					
	N				65					
A	$\bar{X}$					34.3				
	SD					14.0				
	N					66				
GUN#	$\bar{X}$								41.8	
	SD								15.4	
	N								34	
EAR#	$\bar{X}$							35.5		
	SD							15.1		
	N							30		

# "GUN" materials presented auditorily and "EAR" materials presented visually.

each grade.

The control conditions point out a methodological effect which was not anticipated. Control Condition V was significantly better than A ($z = 4.69$, $p < .01$), as well as being better than the results of Part I which used the same materials but with a serial presentation of stimulus and response ($\bar{X} = 38.0$). Control Condition A was not different from the auditory results of Part I although the items were different. To confirm that the facilitative effect was a result of the simultaneous presentation of the stimulus and the response, the "GUN" material was presented auditorily and the "EAR" material visually and serially. These results, shown in Table 3.4, were not different from the results of Part I. It was concluded that list differences did not exist. What appeared to be a list difference ($V > A$) is in fact a procedural difference. The procedural effect made comparisons within the experimental condition less interpretable.

On the assumption that the procedural techniques do not interact with modality of presentation, it was decided to reduce the visual means, from Condition C, by a correction factor required to reduce V to the comparable condition of Part I (V_3). This factor was .83. The corrected visual means for Condition C are presented in Table 3.5 along with the auditory means and standard error of the means. In adjusting the visual data, it was impossible to make

Table 3.5. Auditory and corrected visual means and the standard error of the auditory means for Condition C by grades.

Condition		Fourth Grade		Fifth Grade		Sixth Grade	
		V	A	V	A	V	A
C	$\bar{X}$	5.8	4.7	10.7	12.8	26.0	23.5
	$s_{\bar{X}}$		.9		2.3		1.5

appropriate adjustments of their variance. However, there was available the variance for the auditory means, which had not been adjusted. On the basis of previous experimentation, differences in variance were not expected as a function of modality. In addition, the original A and V variances are nearly identical. Therefore, the auditory variances were taken as a good estimate of the variance to be expected with the adjusted visual means.

It was decided to test the adjusted visual means for compatability to the distribution of auditory means. The standard error of the auditory means was taken as an index of their variability. Given this, it is clear that, for 95% confidence, the visual means should not deviate from the auditory means by more than 1.96 times the standard error of the auditory means. Under this conservative criterion, none of the adjusted visual means were significantly different from the auditory means.

A very marked effect is the increase in performance level in Condition C across grades. These increases from fourth to sixth grade are on the order of twenty-fold per cent the increases observed in Part I for performance on nouns across the same grades. It would appear that subjects in the fourth grade were essentially unable to handle the task, as evidenced by their low performance, while the fifth and sixth grades showed increasing proficiency with a task of this nature. Such marked differences between adjacent grades have not been observed in any previous experiments conducted in either Part I or the present project using less complex tasks.

It is suggested that modality preference may reflect the sequential limitation of auditory presentation. The simultaneous visual presentation of all facets of the stimulus and response places no limitation on the rapidity with which a subject can assimilate. The auditory presentation, necessarily a serial event, may impede the assimilation process and, as well, may reduce the study time available to the subject.

E. Summary and Conclusions

In total, 588 subjects were tested in the three investigations of modality preference. The first two pointed to the fact that modality preferences would only be demonstrated to the degree that the materials in each modality are different. It will be recalled that, for A_1V_1 conditions, differences in learning of the two modalities were significant, and that the materials involved were dissimilar. For the "2" and "3" materials of Experiment 2, no differences were found between modalities. It is noted that the materials were "equivalent" in that the visual presentation correlated directly with the auditory. Thus, at the conclusion of Experiment 2, statements of modality preference were limited to nonmeaningful-nonverbal materials and could be said to be a function of differences between materials in each modality. Experiment 3 used different sets of meaningful-verbal material for each modality. On the basis of the results of 1 and 2, it was expected that modality preference would be demonstrated. This expectation is qualified by the assumption that the difficulty differences between A_1 and V_1 materials were replicated in Experiment 3.

The results of Experiment 3 demonstrated difficulty differences between the sets of materials but only as a function of the manner of presentation. At this point the source of the differences is not relevant. Given difficulty differences, modality preferences will emerge. When list difficulty was equated, modality preferences were not demonstrated. Returning to Experiment 2, it may then be inferred that the modality preferences demonstrated for "1"-type materials were a function of inter-list difficulty and not modality *per se*.

It is concluded that significant modality preference can be demonstrated to the degree that the lists are made up of materials which differ in difficulty across modality. Given that the two modalities are equivalent, it was shown that the specific procedural techniques can be manipulated such that a modality artifact will arise, as in Experiment 3. A great deal of caution must be exercised in the design of bimodal tasks to insure that limitations of the method of presentation do not create such artifacts. Unimodal control conditions are deemed necessary to evaluate the relative efficiency of different unimodal methods of presentation.

Contrary to the Day and Beach hypothesis concerning acquisition, it would seem that superiority of one modality over another is not the case. If the concept of modality preference has any validity, a return to individual testing may be required to demonstrate it.

Experiment IV

Integration of Visual and Auditory Responses Into a Single Response in Paired-Associate Learning

ABSTRACT. Fifth- and sixth-grade subjects were tested in two experimental conditions. The "combined" condition simultaneously presented auditory and visual material for 10 trials. The "separate" condition presented the materials unimodally for the first five trials; the remaining trials used a combined procedure. The results indicate that bimodal tasks should be taught unimodally. Implications for the teaching of hearing-handicapped children are pointed out.

A. Introduction

The experiments conducted previously to examine modality preference have been designed so that the task could be mastered by attending to the material in a single modality. The results have suggested that, under these conditions, the subjects tend to (1) select the more meaningful channel, or (2) select either modality if meaningfulness is equivalently high. There was no indication that subjects attended to both channels simultaneously. However, in these studies there was no need for the subject to do so.

The present study is concerned with performance when materials presented both auditorily and visually must be integrated by the subject in order to achieve the appropriate response. It further explores the more efficient way for introducing such materials for learning, by varying the manner in which initial contact is made with the materials. It is felt that experiments of this type have particular relevance for hearing-handicapped children. Much of their language learning involves the integration of visual symbols, e.g., lip reading, with sounds which they receive. The critical question to be answered is whether it is more efficient to teach the hearing-handicapped children by one modality initially and then to introduce the second modality, or, is it better to present both the auditory and visual materials simultaneously throughout the course of learning. Examining the performance of children with normal hearing under experimental conditions should help to establish normative data permitting us to describe performance under optimal conditions of sensory acuity.

B. Experimental Procedures

1. Subjects. A total of 198 students from grades 5 and 6 of the Detroit Public Schools were used as subjects.

2. Materials. The visual stimuli were four meaningful words (nouns) projected on a screen for four seconds each. The auditory stimuli were four sounds generated by an "American Song Whistle" manufactured by the American Plating and Manufacturing Company. These sounds were tape-recorded and presented over a loudspeaker. The auditory stimuli were all of 4 sec duration, and of different frequency configurations. Two of the stimuli were of constant frequency at either 340 or 680 Hz. The remaining two stimuli made a smooth transition through the octave interval during the first 2 sec and, for the remaining 2 sec, had a constant frequency at either 340 or 680 Hz. Responses were single-digit numbers presented in the appropriate modality.

The S-R pairs are summarized in Table 4.1. The "Auditory" stimuli are described in terms of their frequency configurations.

Table 4.1. Stimulus-response pairings for the two modalities.

Visual		Auditory	
Stimuli	Responses	Stimuli	Responses
GUN	3	680-340	2
ICE	5	340-680	4
ARM	7	680	6
SKY	9	340	8

3. Procedure. The Ampex-Bell & Howell system was used to present materials. As usual, the recall form of the paired-associate paradigm was used with alternating learning and test trials for a total of 10 sets of trials. Two experimental conditions were used which employed different procedures for the presentation of the auditory and visual material during the first five trials only. Procedures during the last five trials were identical for the two experimental conditions.

As indicated previously, stimuli in both modalities were on for 4 sec. Responses immediately followed the stimuli and were presented in their appropriate modality as indicated in Table 4.1. Duration of response items was approximately 1 sec, the time interval required to verbalize the number. Care was taken to synchronize the onset, duration, and offset of visual items with the auditory items. Interpair interval was 4 sec and the inter-trial interval was approximately

20 sec.

In the "combined" condition, subjects were presented the stimulus-response pairs in both modalities simultaneously. During all test trials, these subjects wrote two-digit responses on four lines of their test booklets, one digit for each modality. The order of the digits was not critical in a response; i.e., 89 or 98 were both scored "correct". In the "separate" condition, subjects were presented four items in one modality and then the four items of the other modality. During the first five test trials, these subjects wrote single-digit responses on eight lines in their test booklets. For the last five trials of the "separate" condition, the same procedure as in the "combined" conditions was used. That is, on trial 6, subjects were instructed that the same materials would be presented, but that they now would be presented together; one stimulus and response from each modality simultaneously.

Four learning and four test orders were used in the "combined" condition. Two learning and two test orders were used for the "separate" condition during the first five trials. During the remaining five trials, the four orders used in the "combined" condition were employed. Since the possibility existed that some subjects would learn two-digit numbers, thus enabling them to attend to a single modality in the "combined" presentation, three different schemes of combining S-R units were used, allowing for different combinations of the units in the two modalities. The instructions emphasized the fact that both stimuli must be attended to since the same auditory and visual items would not be constantly presented together.

C. Results and Discussion

Inspection of the fifth- and sixth-grade group means for the two experimental conditions indicated little grade difference within conditions. Therefore, groups were pooled and all results reflect pooled means.

Table 4.2 summarizes the means and standard deviations of correct responses for auditory, visual, and total (auditory plus visual) items, for trials 1-5, 6-10, and 1-10 for the two experimental conditions. Inspection of the table indicates consistent superiority of the "separate" condition over the "combined" condition for both modalities and for total scores. Differences were significant ($p < .01$ for all comparisons using z tests) between conditions within all three trial blocks for auditory, visual, and total scores, verifying the consistent superiority of the "separate" condition.

Table 4.2. Means and standard deviations of the number of correct responses for auditory, visual, and total items within trial blocks for the two conditions.

Conditions		Trials 1-5			Trials 6-10			Trials 1-10		
		A	V	T	A	V	T	A	V	T
Separate	$\bar{X}$	7.1	10.2	17.3	8.4	12.7	21.1	15.5	23.0	38.4
(N=100)	SD	4.9	4.8	8.5	6.5	5.8	10.9	10.9	10.0	18.7
Combined	$\bar{X}$	2.9	5.2	8.1	3.4	7.1	10.5	6.3	12.3	18.6
(N=98)	SD	2.1	3.0	3.8	2.8	4.8	5.7	4.0	6.7	8.1

Figures 4.1 and 4.2 (p. 59) give the learning curves for mean total correct responses as well as for the two modalities for the two experimental conditions. There is a rather smooth progressive increase in total learning scores over the 10 trials except for a slight depression on the sixth trial for the "separate" condition which undoubtedly reflects the change in instructions at this point. The lack of overlap in the curves for the two conditions indicates a clear superiority of the "separate" condition.

The different instructions necessary for the two conditions may account, in part, for the initial superiority of the "separate" condition. However, the consistency of the observed superiority, and especially its continuation in the last five trials, makes it doubtful that instructional differences are of any importance except in the first few trials. Neither is "set to respond" an important variable. The task facing the subject in this experiment could be partially mastered by attending to only one modality so long as the subject considered a single-digit response adequate. To the degree that the subject recognized a two-digit response as being the appropriate answer, the task became bimodal. The set to respond either with one digit or two is not a function of the way the materials are presented since the "separate" condition produced much better performance on the last five trials which used a combined presentation.

D. Summary and Conclusions

The major purpose of this study was to determine the relative

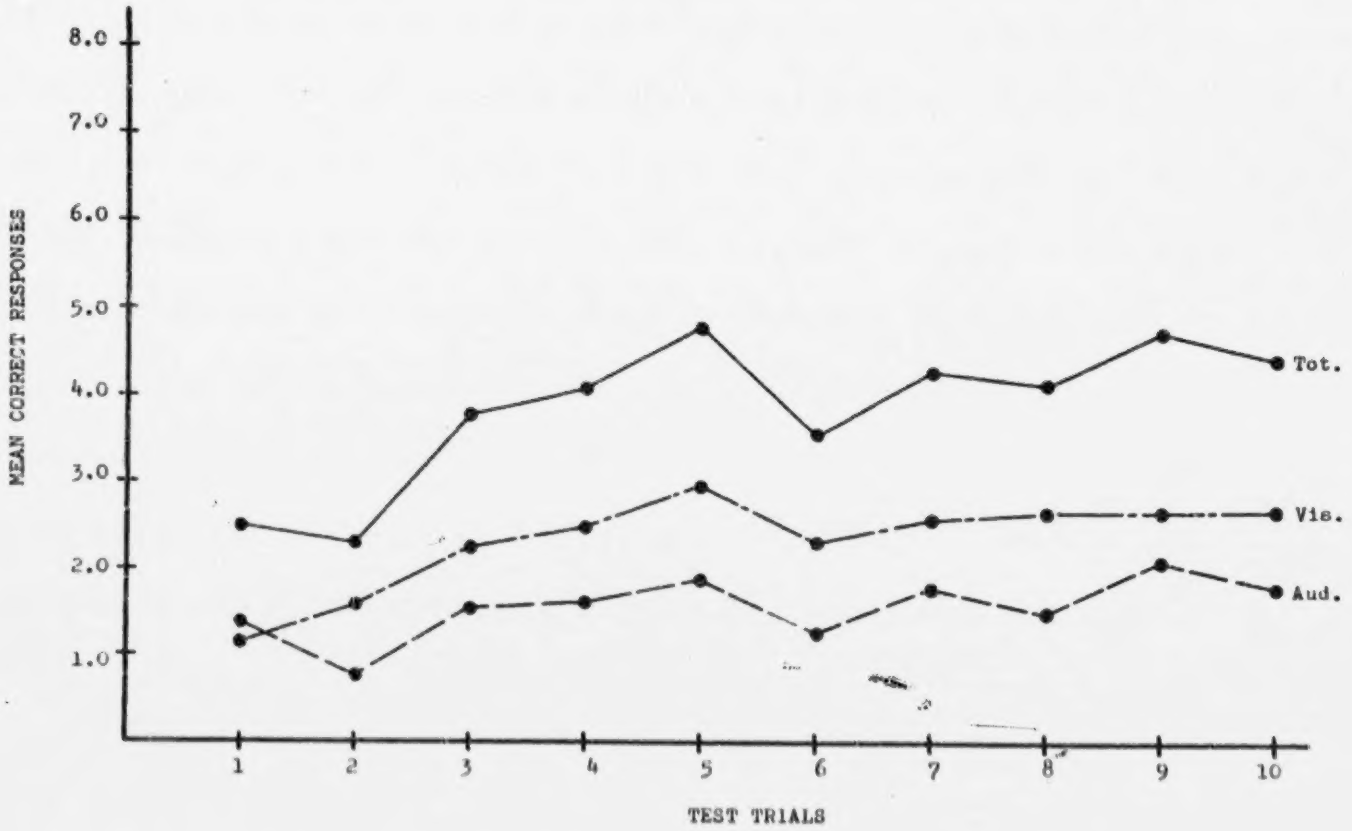


Fig. 4.1 Learning curves for "separate" condition; by modality and total performance.

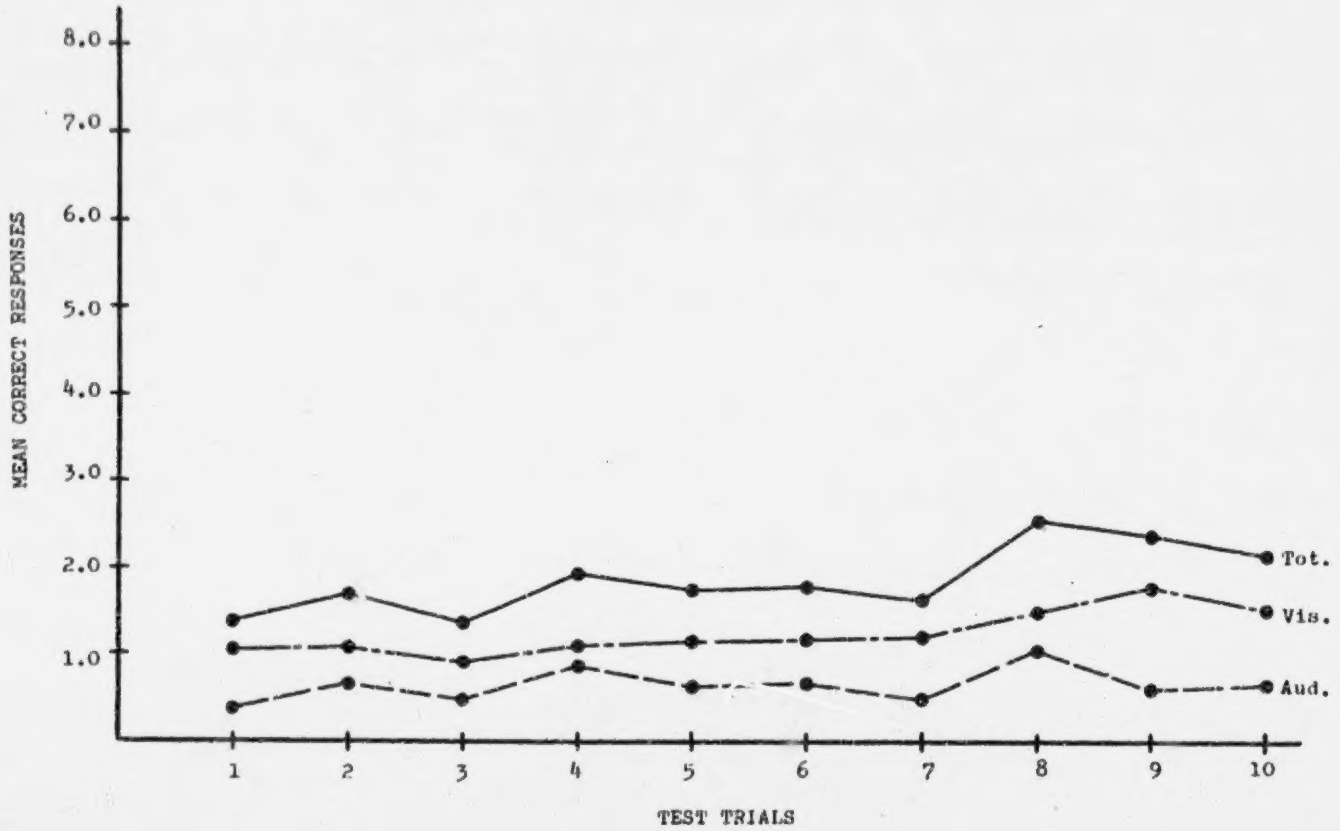


Fig. 4.2 Learning curves for "combined" condition; by modality and total performance.

efficiency of learning segments of a bimodal problem initially and then combining them into a whole versus "whole" learning throughout. The results clearly indicate that better performance is obtained when the task is divided into smaller unimodal segments initially.

This study has considerable implications for the training of hard-of-hearing subjects. To the extent that the tasks used here are comparable to the teaching of language to such children, it would seem that the most successful approach would be to present either the visual or auditory verbal material alone before attempting to use a "bimodal" presentation.

Experiment V

The Effect of Unimodal and Bimodal Cues Upon Learning

ABSTRACT. A paired-associate task was used where each stimulus consisted of two elements. By manipulating the sense modalities by which the elements were presented, four experimental conditions were obtained. Grades 4 and 6 were tested. A clear superiority of the unimodal visual condition was obtained followed by one of the bimodal conditions. The relative efficiency of unimodal versus bimodal cues appears to be a function of factors such as modality and meaningfulness.

A. Introduction

Evidence is available which points to the conclusion that man's perceptual system is basically a single-channel one at any given instant. Davis (1957) suggests that the processing of sensory information occurs in the same place regardless of the modality used. His data supported the hypothesis that simultaneous auditory and visual stimuli must be processed sequentially since both must pass through the same single channel before appropriate responses are made. He inferred that the processing occurs centrally since two simultaneous signals in the same modality are processed at the same speed as are two simultaneous signals arriving via different modalities. This finding suggests that it is not the shifting of attention from one modality to the other that is responsible for the delay in responding to the two stimuli. The paradigm used by Davis involved reaction times in responding to each of the stimuli.

This same conclusion is supported by evidence gained using entirely different paradigms. Gaeth (1960; 1963), using a paired-associate learning task with grade-school children, also obtained evidence which suggested that subjects are alternately unimodal in responding to stimuli presented audio-visually. This same interpretation is offered by Mowbray (1964) to explain the accuracy in identifying visual targets during auditory shadowing.

In all of these studies, however, the subject was able to respond correctly while attending to only one modality. That is, each modality had its own correct response. Lordahl (1961) employed a paradigm which required subjects to attend to both auditory and visual cues before being able to respond appropriately. In his study, an auditory and a visual element were needed to correctly identify a concept. One interesting aspect of his findings was that the type of errors made gave "strong evidence" that subjects responded primarily on the basis of the visual stimuli, tending to ignore the auditory stimuli.

The present study is concerned with the effect of using cues in one or two modalities upon paired-associate learning. Stimuli were chosen which consisted of two elements which must be integrated in order to completely differentiate among them. Each element appears in more than one stimulus complex but unique pairings characterize the specific items. Attending to either element alone will reduce the response set to a few alternatives; however, only by attending to both elements can the single appropriate response be learned. By varying the modality of the stimulus elements, the relative efficiency of unimodal and cross-modal presentation can be evaluated.

If the single-channel concept is an appropriate model for perception, no differences should be obtained among the conditions since the stimulus elements will be processed in the same central area before responding regardless of the sensory modality employed in presenting the material. This is not to imply that the two modalities do not differ as to the efficiency with which they react to differing stimuli. These peripheral differences in the sensitivity and discriminability of the sense organs are not to be confused with the central single channel by which the information is processed. In other words, differences among the conditions in this study can arise if the amount of information transmitted by the two modalities is not equated.

On the other hand, if Lordahl's findings are valid, they imply that there is a set to attend to only one modality at a time. Both his findings and the conclusions reached by Day and Beach (1950) suggest that the visual modality tends to be exclusively attended to, at least when acquiring new material. Therefore, the single-channel concept requires modification. Although information from either sensory modality can be processed in an unbiased fashion by the central nervous system, an attentional bias may be operating independently which selects the modality to be transmitted. Under its influence, the subject would presumably perform better with cues presented in the same modality as compared with cues presented in separate modalities. It might be predicted, then, that the condition where cues for learning are presented exclusively visually would result in better performance than when presented only auditorily, and that both single modality conditions would be better than a bimodal presentation.

B. Experimental Procedures

1. Subjects. A total of 430 children from grades 4 and 6 of the Detroit Public Schools was used in this study.

2. Materials. In selecting the elements for the stimuli, considerable attention was given to choosing materials which could in some way be termed "equivalent" regardless of whether they were presented visually or auditorily. Familiar three-letter words were chosen as one of the elements with little argument concerning the equality of these stimuli across modalities.

The second element of the stimulus proved more difficult in meeting the criterion of equivalence while being of such a nature as to be readily integrated with the word. Simple line drawings were finally selected as the visual elements while sounds of the same conceptual configuration were used for the auditory elements. Three of the auditory stimuli used in Experiment IV were selected. Observations made during the course of that study indicated that children respond physically to stimuli of this nature. Equivalence of visual and auditory configurations is claimed on the basis that both kinds of stimuli produce similar gross motor responses in children; i.e., children made similar arm and body movements reflecting the directions of change in the lines or sounds. These sounds were generated by an "American Song Whistle" manufactured by the American Plating and Manufacturing Company.

Three different sounds were used: a sound that began at 680 Hz and then changed an octave to 340 Hz (hereafter referred to as Sound 1), another began at 340 Hz and changed upward to 680 Hz (Sound 2), and the third was a sound held at 340 Hz (Sound 3). The lines selected for the visual counterpart of these sounds were characterized by the same configurations: \___, /‾‾‾, and ___.

Using two words, GUN and SKY, and the three lines or sounds, six different compound stimuli were generated. Four experimental conditions varying the modalities by which the stimulus elements were presented were used. The conditions are labeled V+V indicating that both stimulus elements were presented visually, A+A when both were auditory, V+A when visual words were paired with the sounds, and A+V when the spoken words were presented with the lines. The responses were single letters presented visually in all conditions. Table 5.1 presents the S-R pairings used in the four conditions.

3. Procedure. The recall form of the paired-associate learning task was used in which 10 learning trials alternated with 10 test trials. The two elements were presented simultaneously by means of a slide projector and/or tape recorder, as determined by the condition, followed by the visual response. The Ampex-Bell & Howell system was used. For a learning trial, the duration of the exposure of the stimulus and response items was 2 sec each for conditions A+V and A+A, with an inter-pair interval of 4 sec and an intertrial interval of 10 sec. On the test trial, the response was eliminated leaving a 2 sec stimulus followed by a 4 sec interval during which the subject could write his response in the answer booklets provided. The procedure for conditions V+A and V+V was the same

Table 5.1. Stimulus-response pairings for the four conditions.

Stimuli		Responses
V+V, A+V	V+A, A+A	
$\backslash\underline{\text{GUN}}$	GUN - 1	M
$/\overline{\text{GUN}}$	GUN - 2	L
$\underline{\text{GUN}}$	GUN - 3	F
$\backslash\underline{\text{SKY}}$	SKY - 1	H
$/\overline{\text{SKY}}$	SKY - 2	V
$\underline{\text{SKY}}$	SKY - 3	X

NOTE: In identifying the conditions, the first letter refers to the modality in which the word is presented. The numbers in A+A and V+A refer to the sounds as described in the text.

with the exception that stimulus and response durations were 3 sec each.

C. Results and Discussion

The mean correct responses, standard deviations, and sample sizes for the four conditions are presented in Table 5.2. Learning curves for the conditions for each grade are given in Appendix A. An analysis of variance was conducted, using Winer's (1962) procedure for unequal sample size, based on the harmonic mean. The summary of the analysis and of the Scheffe procedure for selected comparisons (Winer, 1962) are presented in Table 5.3.

As indicated in Table 5.3, significant differences among conditions and between grades were obtained while the interaction

Table 5.2. Means and standard deviations of the number of correct responses, by conditions and grades.

Conditions		Grades	
		4	6
V+V	$\overline{X}$	22.79	28.19
	SD	13.03	15.78
	N	34	32
V+A	$\overline{X}$	17.94	15.38
	SD	9.62	9.57
	N	53	58
A+V	$\overline{X}$	12.07	13.34
	SD	9.24	9.76
	N	67	58
A+A	$\overline{X}$	10.84	14.67
	SD	7.69	9.72
	N	61	67

Table 5.3. Summary of the analysis of variance and the Scheffe tests for four conditions and two grades.

Source	df		MS		F
Conditions (C)	3		4170.94		39.81**
Grades (G)	1		743.56		7.10**
C x G	3		326.48		3.11
Within Cell	422		104.78		
$\overline{X}$	12.66	12.84	16.60	25.41	
Conditions[#]	A+V	A+A	V+A	V+V	

** $p < .01$.

[#] Lines connect nonsignificant differences at $p = .01$.

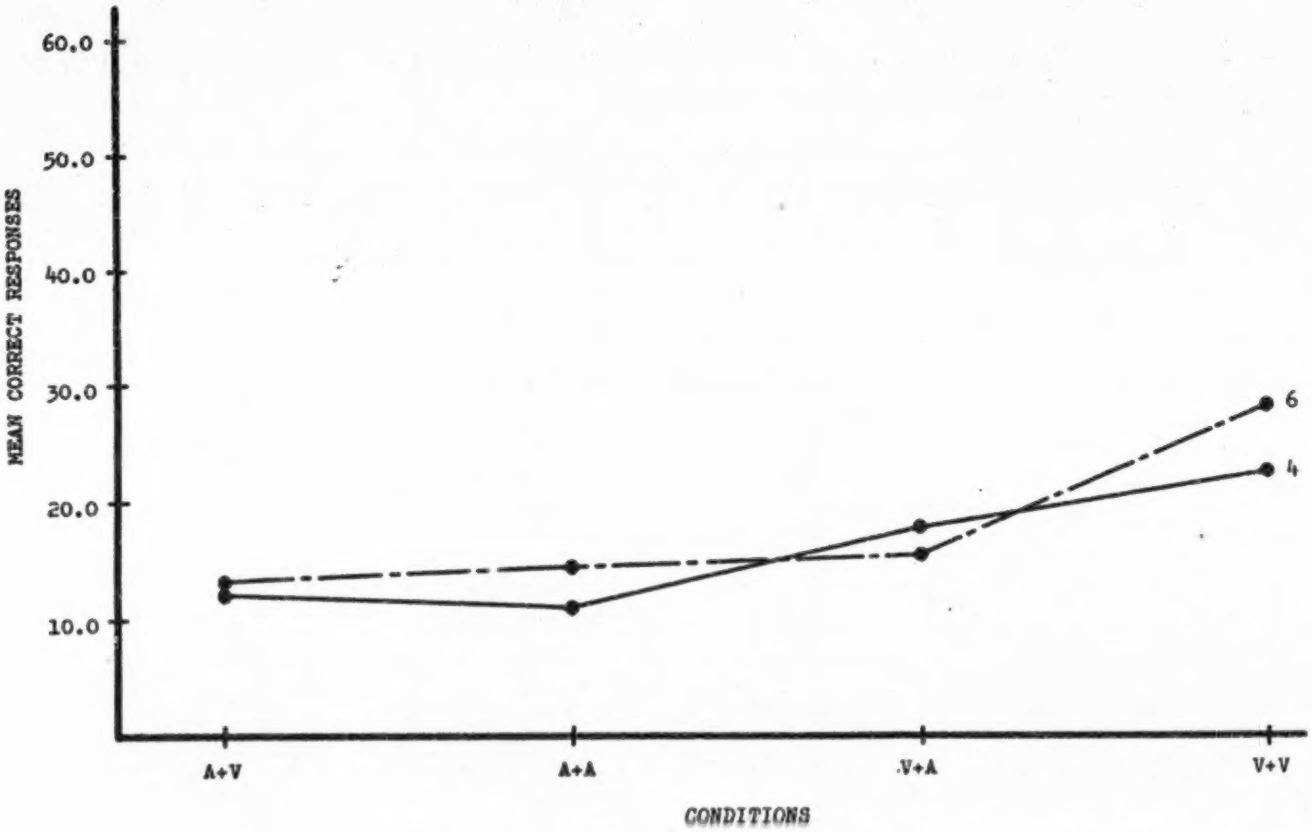


Fig. 5.1 Mean correct responses for grades; by conditions.

was not significant. The grade difference was in the expected direction with the fourth grade performing at a lower level than the sixth grade on nearly all conditions. As seen in Table 5.2, the sole exception is condition V+A. However, this reversal is not sufficient to create a significant interaction and can be considered sampling variation. Of greater interest is the significant variance attributable to conditions. As indicated in Table 5.3, condition V+V was significantly better than the other conditions as had been predicted. However, contrary to our hypothesis, the next best condition was V+A where visual words are accompanied by sounds. Performance on this condition, while significantly poorer than V+V, is significantly better than the other two conditions which did not differ. These relationships are shown in Figure 5.1.

D. Summary and Conclusions

This study was designed to evaluate the effect of employing one or two modalities in presenting elements of a complex stimulus for learning. The results tend to provide further evidence for the superiority of the visual modality in acquiring new material, as discussed by Day and Beach (1950). It also clearly indicates that complex stimuli are best compounded when presented within the same modality *if* that modality is visual. The unexpectedly high level of performance achieved on condition V+A tends to imply that one should utilize the visual modality for the meaningful or more familiar material and the auditory for the less familiar stimulus element if it is necessary to use two modalities for the presentation of material.

Experiment VI

Modality and Meaningfulness in Children with Moderate Hearing Impairment

ABSTRACT. The performance of hard-of-hearing, normal-hearing, and deaf children was compared on four conditions designed to evaluate the modality used to learn. Two conditions presented materials auditorily and visually for 10 trials followed by five trials with only the auditory component. Two control conditions presented the auditory material alone for 15 trials. Auditory material was either nonmeaningful-nonverbal or meaningful-verbal. Results indicate that hard-of-hearing subjects, like the normals, attend to the modality containing the more meaningful material. However, meaningfulness of auditory words is decreased by the poorer discrimination of these subjects. The deaf, as expected, utilize the visual material in a bimodal presentation. No differences were found among the three groups in learning nonmeaningful-nonverbal auditory material.

A. Introduction

Part I demonstrated that, in a bisensory learning situation, attention is directed chiefly to the modality which is more meaningful. With normal-hearing subjects, meaningfulness is defined in terms of the material; with deaf subjects the visual modality is always the more meaningful regardless of materials. No information is presented, however, concerning the performance of subjects who have mild to moderate hearing losses. The general educational policy implies that such children are more like those children with normal hearing since they are usually assigned to regular classrooms. Hearing aids and auditory training are prescribed according to the severity of the loss among other considerations but, on the whole, such children are assumed to make use of both the auditory and visual sensory channels for learning.

This assumption has not been directly examined empirically. No good experimental design was available which allowed inferences to be made concerning modality preference in such children. The importance of testing the assumption that moderate degrees of hearing loss do not interact with meaningfulness of materials and modality of presentation cannot be over-emphasized. The present policy of placing such children in normal learning situations may be entirely inappropriate if it is shown that any degree of hearing impairment is characterized by a complete abandonment of the auditory modality in a bimodal condition.

The experimental procedures from Part I which permitted conclusions about modality preference in normal-hearing and deaf children were useful in examining the validity of the assumption in question. Using the same methods, data were obtained from subjects with varying degrees of hearing loss and their performance compared with the other two groups. If the child with moderately-impaired hearing responds to the bisensory presentation in a way which implies that meaningfulness of material is the crucial factor, this would indicate that such subjects function like those with normal hearing. If, however, they respond to modality rather than material, this would suggest that they function more like deaf subjects.

B. Experimental Procedures

1. Subjects. Seventy-two children with mild to moderately severe hearing losses were tested. No hearing impairment exceeded

60 dB in the better ear. All were enrolled in regular classes in the Detroit Metropolitan area. Because of the limited sample available, children in grades 4 through 6 were used. These subjects were divided into four experimental groups with about equal grade representation, randomizing hearing impairment. Table 6.1 summarizes the hearing levels for the groups.

Table 6.1. Mean hearing loss for the four experimental groups expressed as mean pure tone average (PTA) and mean speech discrimination scores (DISC).

Groups	PTA		DISC	
	$\overline{X}$	SD	$\overline{X}$	SD
1	34.94	11.81	82.22	9.53
2	32.56	11.25	75.61	17.71
3	36.11	12.94	65.44	20.84
4	28.11	15.69	79.11	17.44

Analysis of variance of the pure tone averages (PTA) for 500, 1000, and 2000 Hz yielded an F of 1.32 (df = 3, 68). This value is not significant at the 5% level indicating that the groups did not differ in average hearing loss for those frequencies. Inspection of the complete audiograms suggested that the groups did not differ significantly on the other frequencies tested either. Each group contained all degrees of hearing impairment as suggested by the SDs in Table 6.1. Mean threshold values by air and bone for the entire sample of hearing-handicapped children are illustrated in Figure 6.1 (p. 73). The whole sample is presented because of the great

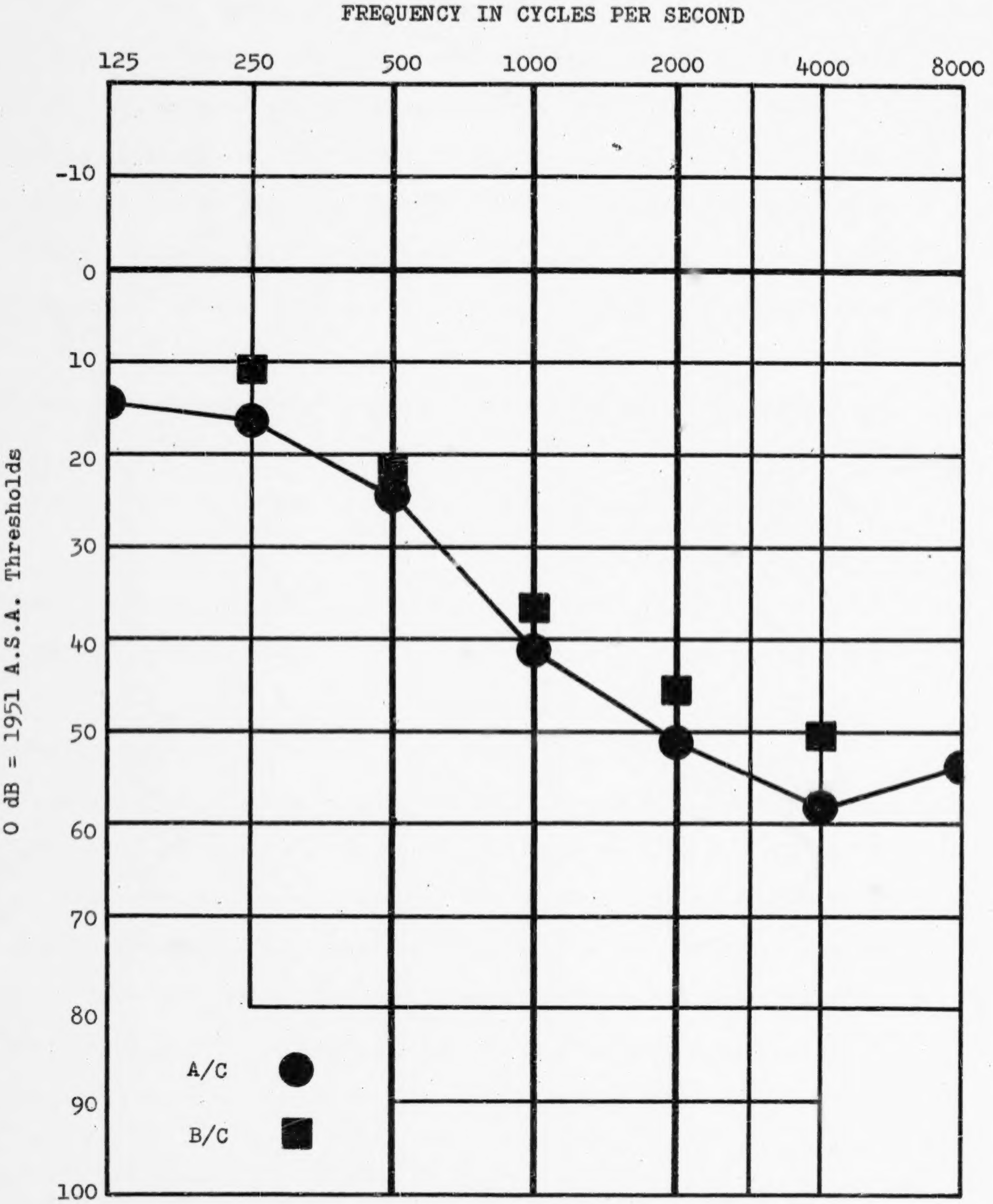


Fig. 6.1 Mean threshold values by air conduction and bone conduction for total sample.

similarity among groups. The corresponding values for the four groups do not diverge greatly from the total values.

Mean speech discrimination scores for the four groups were also examined. These are also given in Table 6.1. Analysis of variance indicated that the groups differed significantly ($F = 3.34$; $df = 3, 68$; $p < .05$) on this variable. Analysis of the selected comparisons (Winer, 1962) showed that the two extreme groups (1 and 3) were the source of this significant variance. This was not considered critical since these particular groups were not tested with speech materials. Furthermore, the significant F ratio may reflect the heterogeneity of variance among these data since discrimination scores are skewed.

2. Materials. V_1, A_1, and A_3 materials, as described previously, were used. Single-letter responses and S-R pairings are as shown in the Apparatus section of this report.

3. Procedure. The recall form of a paired-associate learning task was used with alternating learning trials and test trials, for a total of 15 sets of trials. Groups 1 and 2 received the experimental conditions, in which the first 10 learning and test trials were a combined audio-visual presentation, and the last five sets of trials had the visual dimension removed leaving the auditory material intact. Groups 3 and 4 constituted the control conditions where the auditory presentation was used throughout all 15 sets of trials.

In terms of materials Groups 1 and 2 received A_1V_1-A_1 and A_3V_1-A_3, respectively; while Group 3 learned A_1-A_1 and Group 4,

A_3-A_3. The notation follows that used in Part I. The symbols preceding the hyphen indicate the material and modality presented for the first 10 sets of trials; that following the hyphen indicates the material and modality used in trials 11 through 15. In all conditions the last five trials were auditory. For the two experimental conditions, the auditory and visual material were presented simultaneously by tape recorder and synchronized slide projector (Ampex-Bell & Howell system) for trials 1 through 10, the tape recorder continuing for the remaining trials. For all conditions a short rest period was allowed before the tenth learning and test trial. Three random orders of S-R pairs were used for the learning and the test trials.

During a learning trial the stimulus was on for 2.5 sec followed by the response for 2.5 sec. The inter-pair interval was 5 sec and the inter-trial interval about 15 sec. During a test trial the stimulus was presented for 2.5 sec with an inter-item interval of 5.5 sec to allow the subject time to write the response down in booklets provided. For A_3 material and for the auditory responses, a single pronunciation was used for each presentation. The duration of these items was probably less than the times indicated but the same "segment" of time was allowed for these materials; i.e., the "onset-to-onset" time remained constant. Separate pages in the response booklets were used for each test trial.

The subjects were tested in groups of two to five children. They were instructed to remove their hearing aids after the directions for the task had been given. Prior to the presentation of the experimental material, a tape of recorded pairs of digits was used to adjust the gain of the amplifier to a level at which all the children could identify the numbers as they were played. This same level was used for the experimental material.

C. Results and Discussion

Due to the small sample sizes which were available for this study, comparisons of performance among children with different degrees of hearing impairment was not feasible. Therefore, the hard-of-hearing (H) group was treated as a clinical entity and their performance was compared with that of children classified as normal (N) or deaf (D). The deaf subjects were enrolled in a state residential school for the deaf and had hearing losses greater than 60 dB in the better ear for the speech frequencies. Normal subjects were enrolled in the fourth grade of the Detroit Public Schools. These two groups are described more fully in Part I from which the data are obtained.

Table 6.2 summarizes the performance of the three hearing groups on the four conditions used in this study. No data are available for the deaf group for Condition A_3-A_3, because the subjects were unable to discriminate the words being presented. Figure 6.2 (p. 78) presents the relative performance of these groups graphically.

Examination of the data in Table 6.2 shows some interesting trends. The mean correct responses on trials 1-10 and trials 11-15 for the normal-hearing group for Conditions A_3V_1-A_3 and A_3-A_3 are

Table 6.2. Means and standard deviations of the number of correct responses for trials 1-10 and trials 11-15, by conditions and hearing category.

Conditions		Normal		Hard-of-Hearing		Deaf	
		1-10	11-15	1-10	11-15	1-10	11-15
$A_1V_1-A_1$	$\bar{X}$	27.6	11.9	27.3	16.5	45.0	13.0
	SD	13.7	6.8	14.1	8.7	9.4	8.5
	N	30		18		16	
$A_3V_1-A_3$	$\bar{X}$	37.8	27.1	25.6	19.8	37.4	2.4
	SD	10.4	3.9	14.7	10.2	14.7	2.6
	N	31		18		16	
A_1-A_1	$\bar{X}$	22.2	18.4	22.2	14.2	16.0	12.7
	SD	10.3	7.8	12.8	8.3	10.1	9.1
	N	27		18		21	
A_3-A_3	$\bar{X}$	34.4	24.6	21.8	18.3		
	SD	16.8	7.6	13.4	10.1		
	N	33		18			

similar and higher than the values for the other two conditions. This trend is not observed among the hard-of-hearing, where mean performance for the first 10 trials and for the last five trials is about the same on all four conditions. The deaf group, unlike either of the other hearing groups, performs at a different level for the first 10 trials of each condition and performs alike on the last five trials of $A_1V_1-A_1$ and A_1-A_1. It might be inferred that the deaf perform alike on the last five trials of the two conditions using A_3 material as well since the mean performance on $A_3V_1-A_3$ is very low and no data were obtainable on A_3-A_3 alone. From this viewpoint, the performance of normals and the deaf mirror one

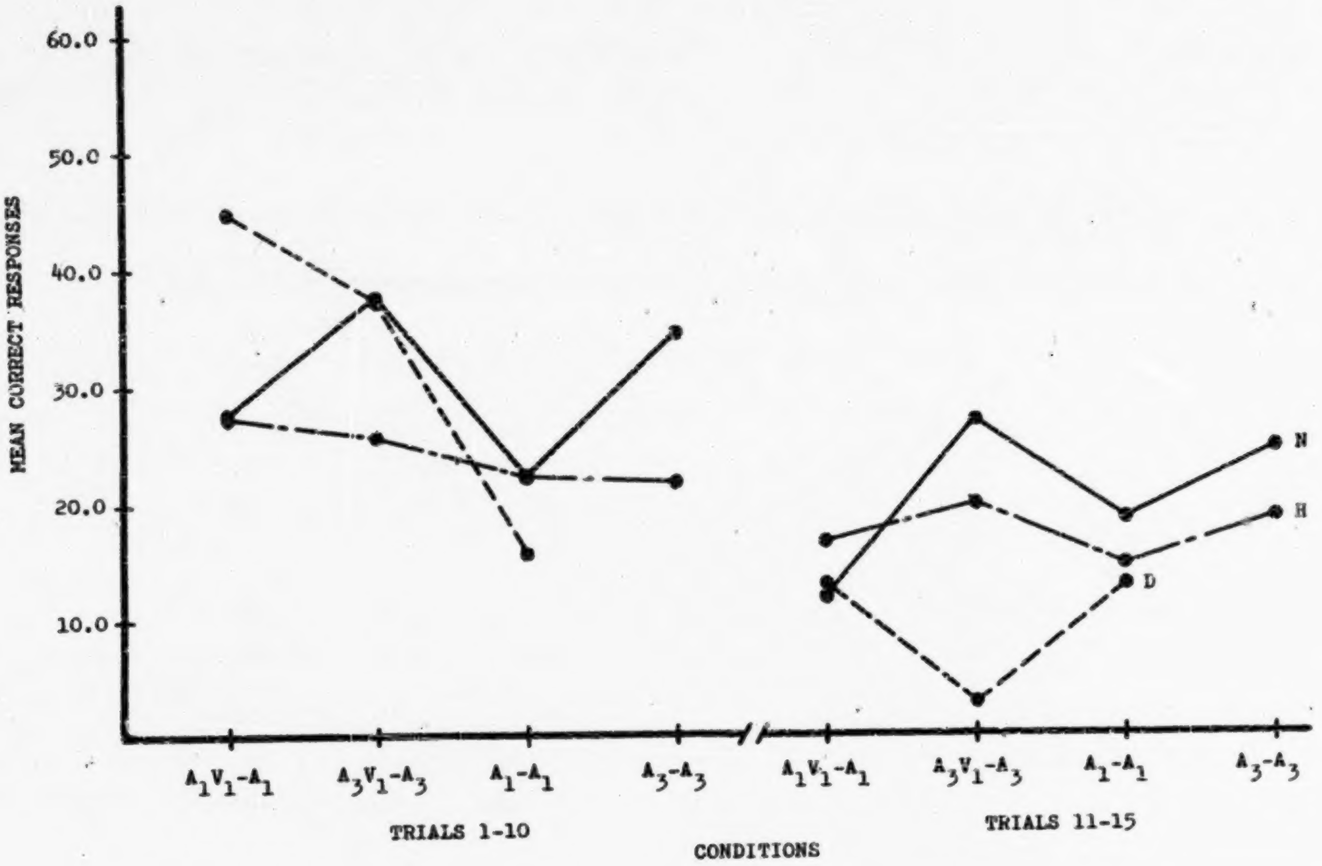


Fig. 6.2 Mean correct responses for trials 1-10 and trials 11-15 for three hearing categories; by conditions.

another on the last five trials where the presentation is always auditory.

One other point of interest in Table 6.2 is the direction of the difference in performance on the two combined conditions during the first 10 trials. The normals performed better on A_3V_1-A_3 than on A_1V_1-A_1 while the deaf show just the reverse. Since these two conditions differ only in the auditory dimension, this suggests that the two groups differed in the efficiency with which they were able to utilize the incoming information being presented in the two conditions. The fact that the hard-of-hearing group shows neither tendency suggests that all conditions were equally meaningful to them.

Analyses of variance were performed upon various subsets of the data in order to ascertain the dominant modality for the different hearing groups and experimental conditions. Performance on the first 10 trials of each combined condition was compared with its control, the appropriate auditory condition, to evaluate the effect of adding the visual material. Comparison of the performance on the last five trials of the combined and control conditions again gives information concerning the extent to which the auditory material was attended to in the first 10 trials. It also indicates any facilitation due to the addition of visual stimuli. Furthermore, these analyses allow inferences to be made concerning the similarities in performance among the three groups of children.

Table 6.3 presents the results of the analysis of variance for

Table 6.3. Summaries of the analyses of variance for Conditions A_1V_1-A_1 and A_1-A_1 for all three hearing categories for trials 1-10 and trials 11-15.

Trials	Source	df	MS	F
1-10	Hearing Level (HL)	2	443.61	3.10*
	Conditions (C)	1	259.91	1.82
	HL x C	2	1936.70	13.54**
	Within	124	143.06	
11-15	Hearing Level (HL)	2	80.40	1.23
	Conditions (C)	1	51.06	.78
	HL x C	2	217.22	3.32*
	Within	124	65.32	

** $p < .01$.

* $p < .05$.

the three groups of children on Conditions $A_1V_1-A_1$ and A_1-A_1 for trials 1-10 where both visual and auditory material were presented in the first condition and for trials 11-15 where both conditions consisted of only the auditory dimension. As indicated there, a significant difference in hearing groups and a significant interaction between hearing level and condition were found on the first 10 trials, while only the interaction was significant on the last five trials. The interactions are the only interpretable effects in these analyses. It was found that, for the first 10 trials, the normals and hard-of-hearing performed about the same on the two conditions while the deaf performed significantly better on the combined condition than on the auditory dimension only. On the last five trials, the hard-of-hearing group became more like the deaf, both of them performing about the same on the two conditions while the normals performed significantly better on A_1-A_1 than on the other condition.

Since no data were obtained from the deaf on Condition A_3-A_3, an analysis similar to the previous one was not possible for that condition and its companion, $A_3V_1-A_3$. Table 6.4 presents the summaries of the analyses of variance for these two conditions for the normal and hard-of-hearing groups and indicates that the performance of the two groups on the first 10 trials is the only significant source of variance, with normals scoring higher. Table 6.5 presents the results of the analysis of the three groups of subjects on the single condition, $A_3V_1-A_3$, and shows that the three groups differ significantly on the first 10 trials and on the last five trials,

Table 6.4. Summaries of the analyses of variance for Conditions A_3V_1-A_3 and A_3-A_3 for normal and hard-of-hearing categories for trials 1-10 and trials 11-15.

Trials	Source	df	MS	F
1-10	Hearing Level (HL)	1	3587.27	18.16**
	Conditions (C)	1	296.42	1.50
	HL x C	1	.69	.00
	Within	96	197.58	
11-15	Hearing Level (HL)	1	1058.00	1.75
	Conditions (C)	1	92.66	1.53
	HL x C	1	5.76	.10
	Within	96	60.55	

** $p < .01$.

with normals and deaf performing alike and better than the hard-of-hearing on the first 10 trials. For the last five trials, however, where only the auditory material is presented, the normals were better than the hard-of-hearing and both were much better than the deaf.

Table 6.5. Summaries of the analyses of variance for the three hearing categories on trials 1-10 and trials 11-15 of Condition A_3V_1-A_3.

Trials	Source	df	MS	F
1-10	Hearing Level (HL)	2	957.92	5.84**
	Within	62	164.10	
	Total	64		
11-15	Hearing Level (HL)	2	3224.60	85.19**
	Within	62	37.85	
	Total	64		

** $p < .01$.

The results of these three analyses suggest that the deaf attend to the visual material whenever it is available while both the normals and the hard-of-hearing tend to seek the more meaningful material. In the case of nonmeaningful material in both modalities, as in the first 10 trials of A_1V_1-A_1, the scores of the two groups with hearing (N and H) are depressed suggesting difficulty in selecting a modality to which they can efficiently attend. In the case where one modality is highly meaningful, as in Condition A_3V_1-A_3, the two groups with hearing differ as a function of the difference in their abilities to detect and discriminate auditory stimuli. The normals are better than the hard-of-hearing at these tasks and, consequently, perform better on the first 10 trials of this condition by attending solely to the meaningful auditory material. The hard-of-hearing apparently need more trials to achieve the same degree of proficiency with the auditory material as implied by the fact that they are still learning in the last five trials while the normals have little room left for improvement.

This latter point is illustrated by the relative performance of the two groups on the two entirely auditory conditions. Table 6.6 presents the results of the analysis of variance of the performance of the normal and hard-of-hearing groups on all 15 trials of Conditions A_1-A_1 and A_3-A_3. As shown there, both hearing levels and conditions were significant sources of variance and the interaction was not significant. The normals performed better than the hard-of-hearing subjects on both auditory conditions and both groups performed better on the meaningful auditory words than on the nonmeaningful

Table 6.6. Summary of the analysis of variance for normal and hard-of-hearing categories on all 15 trials of Conditions A_1-A_1 and A_3-A_3.

Source	df	MS	F
Hearing Level (HL)	1	3136.34	7.10**
Conditions (C)	1	2855.65	6.46**
HL x C	1	1220.64	2.76
Within	92	441.87	

** $p < .01$.

sounds. A simple analysis was performed for Condition A_1-A_1 for all three hearing categories, which showed that the differences among groups were not a significant source of variance (F = 2.45; df = 2, 65). This latter finding suggests that the differences in hearing acuity are not relevant when the material is both nonmeaningful and highly discriminable; i.e., covering a wide range of frequencies and using different temporal sequences.

Additional evidence is provided concerning the modality to which the hard-of-hearing attend by examining the results of the three groups on the condition where auditory words are combined with visual symbols (A_3V_1-A_3). On trials 1-10, the normals and deaf both performed better than the hard-of-hearing implying that the normals learn auditorily and the deaf visually with about the same degree of efficiency. The depressed performance of the hard-of-hearing group on this task would suggest that they may vacillate between the two modalities rather than settling down to learn the material via one modality. The confusion as to the more meaningful modality results, in all probability, from the decreased efficiency of the auditory channel in these subjects as compared with normals.

Examination of the performance on the trials before and after the removal of the visual stimuli in the two combined conditions provides more information concerning the modality attended to in the first 10 trials. If there is a temporary decrease in performance from trial 10 to trial 11, this might be considered evidence for the visual stimuli receiving the chief attention in the preceding trials. Learning curves for the three hearing groups on the four conditions are presented in Figures 6.3 through 6.6 (pp. 85-86). The two auditory control conditions are presented to show that the shift in performance is not found when there is no change in the task. As illustrated in the figures for the two combined conditions (Figures 6.3 and 6.4, p. 85), all three hearing categories exhibit some interference with performance when the visual modality is withdrawn in Condition A_1V_1-A_1. However, only the two groups with hearing losses (H and D) show a decrease in performance from trial 10 to trial 11 in Condition A_3V_1-A_3. The hard-of-hearing group shows only a very slight interruption in the learning curve for this condition.

Correlated _t_ tests were used to evaluate the significance of these differences. As shown in Table 6.7, all differences were significant except for the hard-of-hearing on A_3V_1-A_3. Interestingly, for this same condition, the normals showed a significant _increase_ in performance when the visual modality was withdrawn. This inhibitory effect with bimodal presentations has been noted before by Graunke (1959) and Gaeth (1963), as discussed by the latter. The

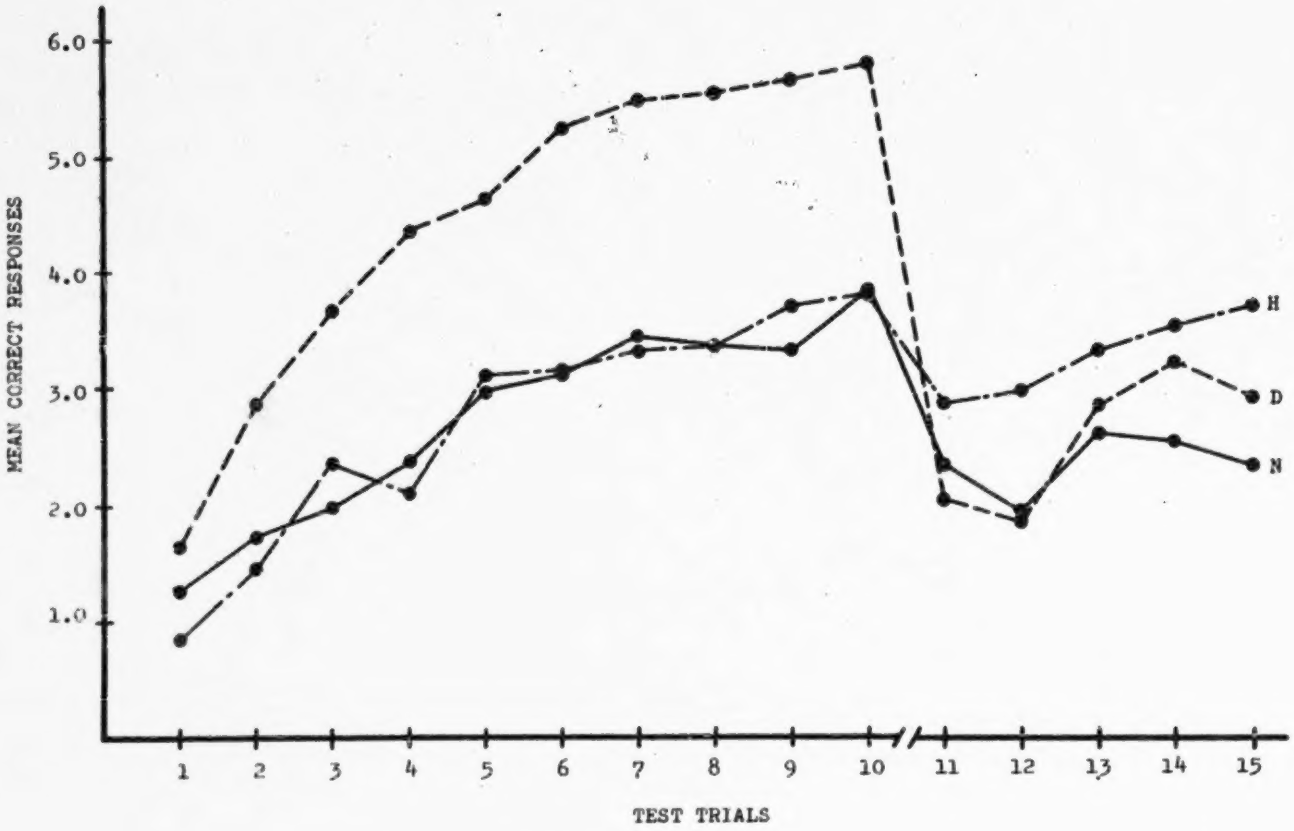


Fig. 6.3 Learning curves for Condition A_1V_1-A_1 by hearing category.

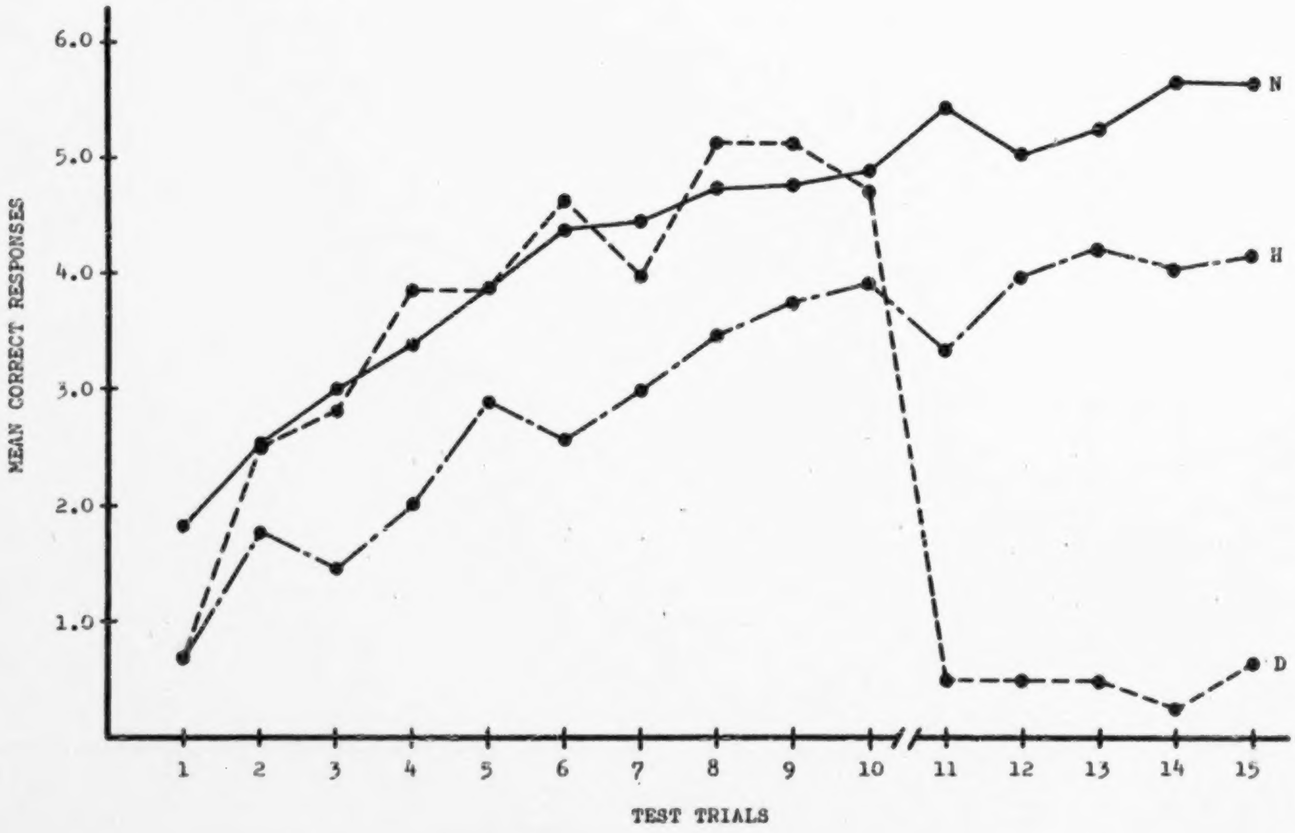


Fig. 6.4 Learning curves for Condition A_3V_1-A_3 by hearing category.

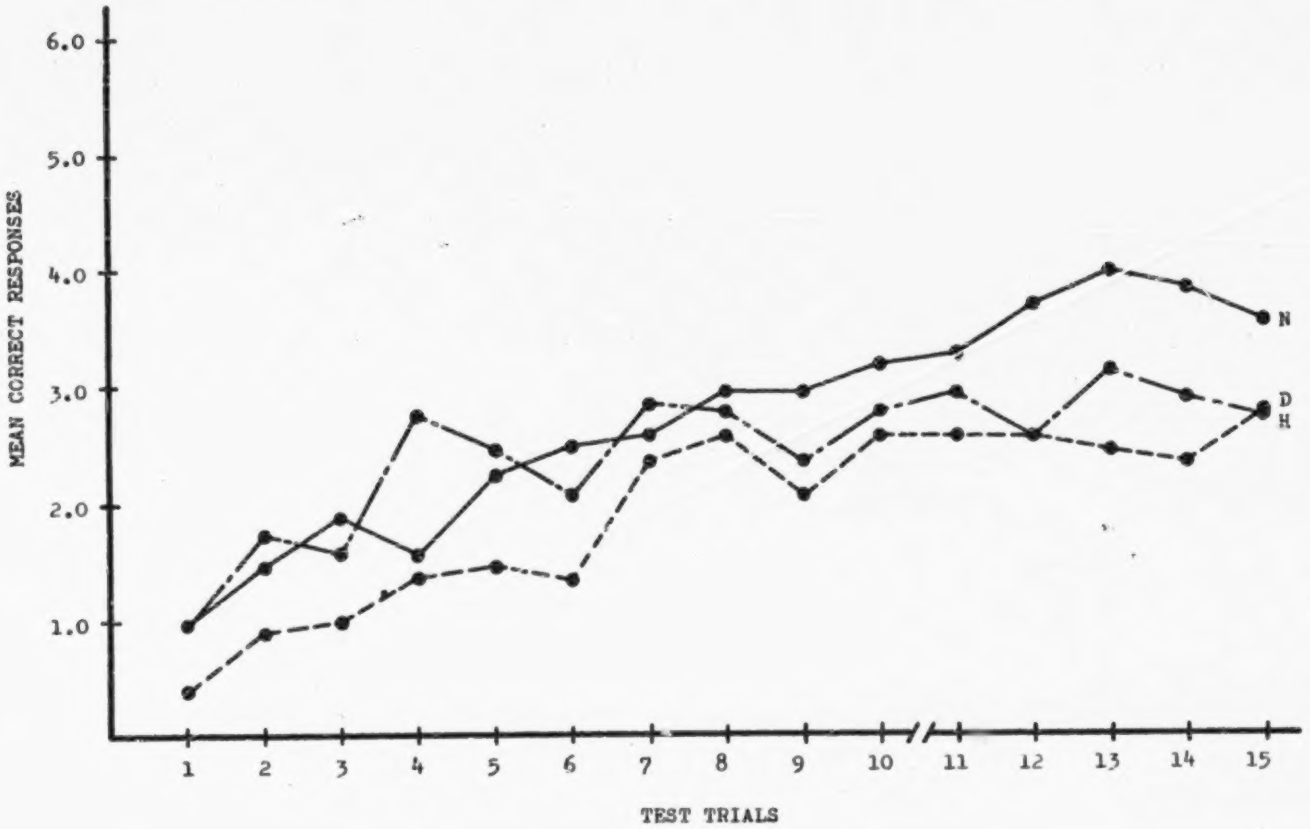


Fig. 6.5 Learning curves for Condition A_1-A_1 by hearing category.

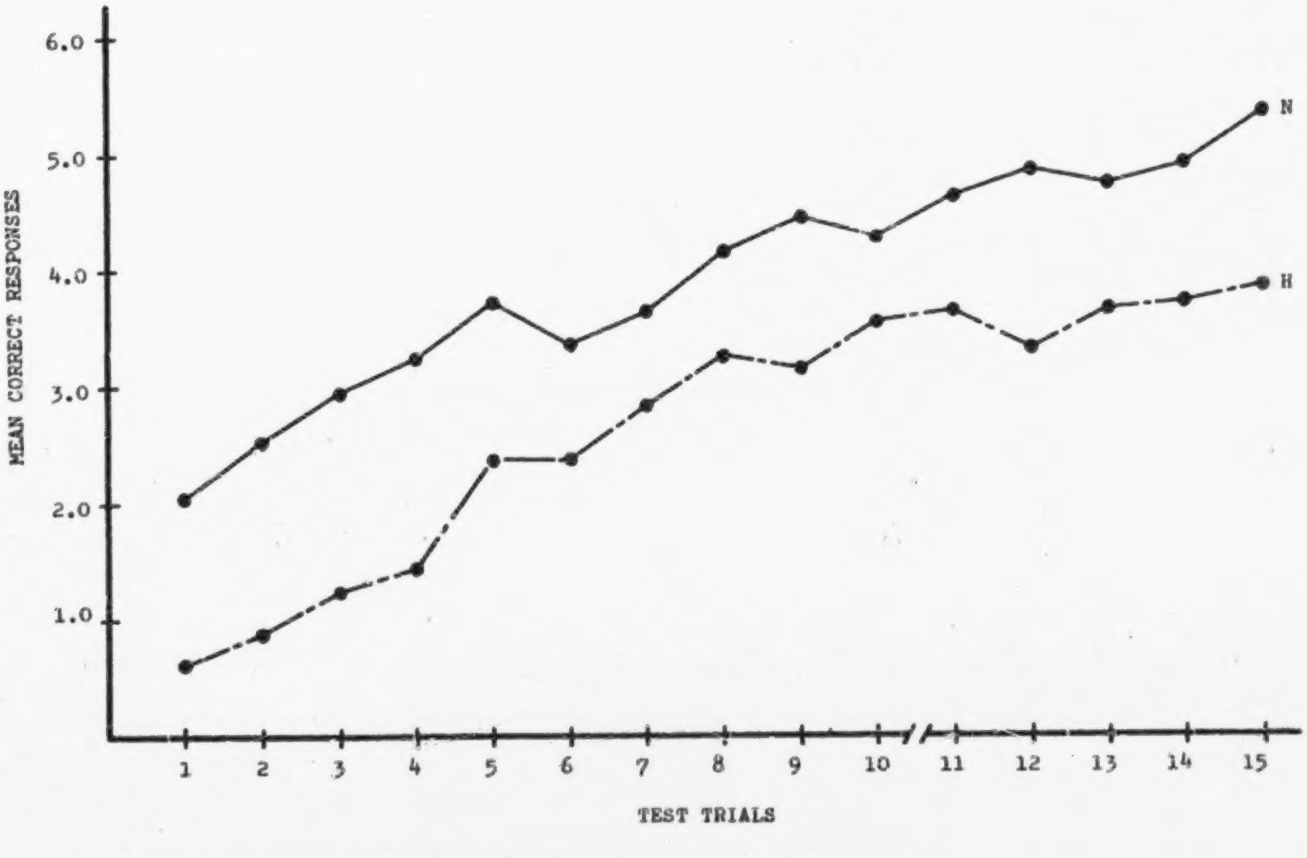


Fig. 6.6 Learning curves for Condition A_3-A_3 by hearing category.

Table 6.7. Mean scores at the transition from combined to auditory presentation for the three hearing categories.

Conditions	Groups	Mean Score T 10	Mean Score T 11	$\bar{X}_D$	t
$A_1V_1-A_1$	N	3.87	2.37	-1.50	4.17**
	H	3.83	2.88	- .95	2.88*
	D	5.81	2.06	-3.75	8.15**
$A_3V_1-A_3$	N	4.90	5.45	+ .55	3.67**
	H	3.94	3.33	- .61	1.60
	D	4.75	.50	-4.25	7.09**

** $p < .01$.
* $p < .05$.

results of the t tests lend further support to the hypothesis that only one modality is attended to in a bimodal presentation with the deaf selecting the visual modality and the normals the more meaningful material. The hard-of-hearing seem to represent a transition between these two extremes. However, some suggestion of attention to the non-preferred modality is indicated by the inhibition effect noted in normals and by the superior performance of the deaf in the condition where the visual symbols are accompanied by sounds rather than words.

D. Summary and Conclusions

The performance of groups of children with normal hearing, mild to moderate hearing losses, and severe losses (deaf) were compared on four experimental conditions. The procedure allowed inferences to be made concerning the modality used in learning the task.

Of particular interest was the performance of those subjects classified as hard-of-hearing, i.e., with mild to moderate losses, in relation to the other two classes of hearing ability.

The results indicate that the hard-of-hearing subjects perform more like those with normal hearing than like deaf subjects. Differences which were obtained between normals and those with moderate hearing losses are explainable in terms of the decreased efficiency of the hearing ability of the hard-of-hearing group. However, there is no evidence to suggest that this group fails to use the auditory modality whenever possible.

The evidence presented here indicates that the hard-of-hearing group selects the modality containing the more meaningful material as does the group with normal hearing. However, meaningfulness is modified by the audiometric characteristics of this group. Familiar words presented auditorily are highly meaningful to subjects with normal hearing. To subjects with some hearing loss, these same words become less meaningful because of reduced discriminability. In a purely auditory presentation, the hard-of-hearing subjects take longer to achieve the same level of performance with such materials as do normals. In a bimodal presentation, the performance of the hard-of-hearing subjects suggests confusion or indecision as to which modality is more meaningful. This aspect of their behavior may be a function of the auditory training which they receive. It may be that the hard-of-hearing child without training would perform like a deaf child; i.e., would prefer the visual modality exclusively for the acquisition of material. However, training may modify the strength of this initial preference so that he samples both modalities before selecting one as more meaningful, as does a child with normal hearing. If these assumptions are valid, training is a necessary component in the education of the hard-of-hearing child in order to provide him with the flexibility which the normal child has in bimodal learning situations.

RESULTS PERTAINING TO ASSOCIATION VALUES

Three-letter trigrams (CVC and CCC) have been used regularly in studies of verbal learning. The early work of Glaze (1928) provided association values for many of the CVC trigrams. Recently, Archer (1960) reported scores for all possible CVC trigrams. Witmer (1935) gave meaningfulness values on many CCC trigrams. These investigators, as well as others, (e.g., Hull, 1933; Krueger, 1934; Noble, 1961), used subjects drawn from a college population to establish the association values. Since the majority of research studies employing trigrams as learning material have also sampled the college population, the use of these norms is probably valid.

Until very recently, there has been little information to guide the use of nonsense syllables with children. Since gathering the data reported here, we have encountered two relevant studies. Palermo, Flamer, and Jenkins (1964) evaluated association values for children and adults by inference from performances on a common learning task. They concluded that adult values can be used successfully with children. However, the validity of these conclusions depends upon the two assumptions that were made: (1) Association values for children and adults are similar, and (2) the relationship between association values and paired-associate learning would also hold for children. Even granting the validity of the assumptions, a more direct attack upon association values for children seemed indicated.

Shapiro (1964) used a "restricted production method" to obtain meaningfulness values for grade-school children and concluded that the rank order of CVC trigrams is stable across grades. However, the obtained values correlated only .52 to .66 with Noble's values. This would suggest that the meaningfulness of trigrams varies considerably from children to adults. If association values as measured by Archer and meaningfulness values as determined by Noble converge upon the same concept, Shapiro's findings cast doubt upon the assumption made by Palermo et al., that association values for children and adults are highly similar.

The present study grew out of Part I, which examined paired-associate learning in children as a function of modality of presentation, verbalness, and meaningfulness of material. The results were such that the scaling of materials with children was indicated before valid conclusions could be drawn.

Experiment VII

Association Values for Selected Trigrams with Children

ABSTRACT. Association values, in terms of percentage of subjects who responded "Yes" to each trigram, were obtained using samples of CVC and CCC trigrams. The subjects were children in grades 4-6 and from a residential school for the deaf. Five independent experiments were reported in which different aspects of the general problem were investigated. Correlations of from .83 to .87 were obtained between the values from children and the corresponding values from Archer for the CVC material. A relation of .88 was found between Witmer's values and those obtained here for the CCC items. Group and individual reliability estimates were also obtained; test-retest reliability for the group values was .99. More than 76% of the individuals were consistent in their responses to each trigram from test to retest. The association values for the deaf children correlated .90 with those for hearing children in grades 4 and 5.

The data suggest that association values cannot be interpreted in any absolute sense with children since the values were influenced by the pool of items to be evaluated. However, they are good indicators of the relative degree of meaningfulness.

A. Introduction

Association values were obtained under several conditions as the by-product of attempts to study and standardize trigrams for use in experiments with children. The data are presented in sections in keeping with the format in which they were gathered. As far as is known, there is no report in the literature in which association values have been gathered with deaf children nor in which both CVC and CCC trigrams were presented in a single list.

B. General Methods

Even though several kinds of lists were utilized, the same general procedures were used throughout the study. The items were randomized and arranged in two columns per page. Each trigram was typed in capital letters and followed by "Yes___ No___" for the subject to use in responding to the item. Samples of the forms used to collect the data appear in Appendix C.

The children participated in the study on a group basis. Each group was simply a regular classroom of children. Three monitors were present at the time the task was administered.

The same directions were given orally to the children for all conditions throughout the study. A copy of the directions will be found in Appendix B. Basically, the instructions followed those used by Archer (1960, p. 2). The questions "Is it a word?", "Does it seem like a word?", "Does it remind me of a word?", and "Can I use it in a sentence?" were used. His suggestion that the subjects pronounce the trigram to themselves and the question "Does it sound like a word?" were not used. This instruction was not appropriate for CCC trigrams nor was it considered valid for deaf children. However, with hearing subjects the modification probably did not drastically alter the set to respond since many subjects reported using pronunciation as one criterion when queried after completion of the task. In addition, the following directions were given: "Don't think to yourself that these are all letters and words are made up of letters, so I'll answer them all 'Yes', or none of these are actually words so I'll answer them all 'No'. This isn't what we want. Just look at each set of letters separately and try to decide if it seems like a word."

No time limit was imposed upon the subjects. However, they were encouraged to complete the task quickly and not to ponder over the items. The data on the children with normal hearing were gathered by the same research staff who were administering the paired-associate learning tasks. The data on the deaf children were gathered by the psychologist at the school.

C. Experiment 1

1. Introduction. The initial experiment had the three-fold purpose of (a) obtaining association values from fourth- and fifth-grade subjects on the CVC trigrams for which learning data were available, (b) estimating the reliability of these association values, and (c) getting association values on the same material from deaf subjects.

2. Materials and Subjects. Six CVCs (KEZ, WUB, WOJ, DAQ, ZEG, and JID) had been selected originally for paired-associate learning in Part I on the basis of Glaze's values, representing sampling from only two levels (0 and 7%). When Archer's values were published, the scores were quite different (13, 21, 25, 29, 35, and 38%). These six items became the nucleus of a 50-item list of CVC trigrams (CVC-50). The remaining 44 items were sampled from Archer's list with the restriction that one trigram come from consecutive pairs of levels so that the finished list would contain one CVC at the 1-2% level, another at the 3-4%, et cetera. The sampling procedure con-

sisted of first selecting by chance the odd or even value for each step and then selecting an item from that value "at random"; items that Archer reported as not reliable or showing a difference by sex were avoided.

The 50 trigrams were arranged in three different orders and duplicated for presentation. Copies are included in Appendix C. The three orders were then alternated so that every third child used the first order, et cetera.

A total of 478 children were used in the experiment. Of this number, 361 were in grades 4 and 5 in the Detroit Public Schools, and 117 were in grade 6 or above in a residential school for the deaf. There is no good way to equate deaf and normal children for a verbal task; however, previous experience suggested that the reading levels of the two groups would be approximately equal.

A sample of 118 of the 361 normal children were used for an estimate of the reliability of the results. Three days after the original presentation of the task, the subjects were given the lists again with identical instructions. Neither the teachers nor the children were forewarned that the task would be repeated.

3. Results and Discussion. The 50 CVC trigrams used are shown in Table 7.1 in ascending order according to Archer's scale, not in any of the three presentation orders. The association values in the first column represent the percentage of Archer's subjects who responded with "Yes" to the item. The adjacent columns in Table 7.1 contain the corresponding percentages obtained from the grade 4-5 sample, from the reliability sample, and from the deaf

Table 7.1. Association values for List CVC-50.

			Reliability		
CVC	Archer	Gr. 4-5	I	II	Deaf
XYH	1	5	2	3	10
QOJ	4	8	11	8	8
XEG	5	13	14	13	18
NYJ	7	12	10	9	20
QAZ	10	26	23	28	32
XIM	11	17	14	14	39
WOJ	13	20	15	18	23
KIH	15	26	18	20	52
LYG	17	16	15	15	19
PYM	20	36	35	35	41
WUB	21	53	52	61	46
BEJ	24	27	24	26	50
ZEG	25	40	37	40	40
VYS	27	16	14	12	11
KEZ	29	21	20	20	26
TAZ	32	53	56	56	88
ZUP	34	48	46	48	55
JID	35	54	43	55	51
DAQ	38	20	15	18	26
NEZ	39	31	25	31	57
FIP	42	78	77	81	84
QAM	44	30	27	31	32
YAT	46	58	52	62	57
HEJ	48	32	25	31	34
BYG	49	30	28	30	28
KUL	52	31	26	32	60
CYL	53	26	26	27	47
TUS	55	64	62	70	77
DYL	58	23	22	20	32
FYT	60	30	28	28	14
GAN	61	75	69	75	87
KYT	64	31	29	24	20
LUN	66	56	54	65	91
HUK	67	69	72	66	46
SAF	69	70	57	70	95
LAV	72	59	54	56	81
PAG	74	83	78	80	96
BIF	76	52	39	55	61

Table 7.1. (cont.)

			Reliability		
CVC	Archer	Gr. 4-5	I	II	Deaf
MOV	78	79	75	78	97
TER	79	74	66	73	89
COF	81	76	71	76	86
WAM	83	78	77	77	64
REB	86	80	80	83	90
HIK	88	69	65	62	85
HEX	90	56	52	54	50
DOR	92	83	77	84	89
PIL	93	81	72	76	95
NAB	96	79	79	77	82
YUM	97	86	83	85	78
RUN	99	99	99	99	100
$\overline{X}$	50.5	47.6	44.2	47.1	55.2
SD	29.2	25.8	25.4	26.5	28.7
N	216	361	118		117

sample. The relationships among the several samples were evaluated by both rank-order and product-moment correlations. In no case did the two estimates differ by more than .02; therefore, only product-moment correlations are reported.

The initial concern was with the correlation between the values reported by Archer and those obtained from grades 4 and 5. This relationship was quite high (r = .83) suggesting a good deal of predictability of association values for children given adult norms. The mean of the association values as selected from Archer was 50.5; the mean from the 361 children, 47.6. Scanning the data down the columns indicates that the children did not rate the low items as low nor the high items as high as the college students did.

The statistical estimate of the reliability of the scores obtained from the sample of 118 was very high, the correlation between Session I and Session II being .99. The stability of the scores was also examined by tallying the responses by item by subject for the two sessions. Examined in this way, a subject can be either consistent in his response to a CVC for the two sessions, i.e., answer "Yes" both times or "No" both times, or his response can be changed over time, either from "No" to "Yes" or the reverse. For each CVC the percentage of subjects who changed responses, from "No" to "Yes" or "Yes" to "No", from one session to the other, was calculated.

The mean percentage who changed responses, and the standard deviation, gives an index of the reliability of individual responses to CVCs. An average of only 23.5% of the subjects (standard deviation = 4.4%) showed such changes per item. Conversely, one might say that 76.5% of the subjects, on the average, were consistent in their response to a particular CVC in a test-retest situation. There was almost no uncertainty concerning the terminal items (XYH and RUN); only 3% of the subjects changed their response to XYH and only 2% were "uncertain" about RUN.

The data for the deaf sample were first divided into two parts, grades 6-9 (N = 50) and grades 10-12 (N = 67), and examined separately. However, the product-moment correlation between the two groups was .96, and therefore the data were combined into a single set. When the association values for the deaf were correlated with those for grades 4 and 5 and with Archer's values, coefficients of .90 and .72, respectively, were obtained. The degree of similarity between the deaf and normal children in evaluating the trigrams is apparent, but it would seem that the two groups of children have some commonality of difference from the college groups.

Table 7.1 shows a total mean of 55.2 for the deaf as contrasted with a mean of 47.6 for the normal group ($z = 1.41$). The deaf subjects tended to respond "Yes" to the CVCs more frequently than did hearing subjects although not significantly so. However, the high correlation between the two sets of values indicates that the difference is a relatively constant one. If the trend in means is reliable with additional sampling, two possibilities are indicated. It may be that the constant order of the responses "Yes___ No___" influenced the deaf group more than it did the normal group, or there may be a "true" difference in the groups in that printed material may seem intrinsically more meaningful to deaf subjects, while hearing subjects may be influenced by pronunciation as well as by appearance.

D. Experiment 2

1. Introduction. While the data for Experiment 1 were being collected, another paired-associate learning study was being designed for use with children (see Experiment II of this report). A new set of CVC items was needed to meet the requirements of the study. These had association values of 14, 17, 22, 25, 27, and 28% according to Archer. Since none of the new items had appeared on the CVC-50 list, another list of trigrams was generated to expand the pool of items upon which data from children would be available.

2. Materials and Subjects. The six items selected for the paired-associate study (SIJ, GEC, VAF, KEB, YUD, and ZOT) plus two alternate items (FEP and VOB) formed the core of this new sample. Starting with the CVC-50 list from Experiment 1, a trigram was randomly selected from each of the scale values not represented so that a final list of 100 trigrams would be obtained (CVC-100), each from a different association value. Because the items selected for the learning task included two at 14% and two at 17%, the final list did not include items of 15 or 18%. Forty-five of the trigrams appeared on both CVC-50 and CVC-100. Two random orders of the 100 items were prepared. Copies are included in Appendix C.

The CVC-100 list was presented to 763 subjects in grades 4-6 of the Detroit Public Schools.

3. Results and Discussion. The association values obtained for these items are presented in Table 7.2 along with Archer's values.

Table 7.2. Association values for List CVC-100.

CVC	Archer	Gr. 4-6	CVC	Archer	Gr. 4-6
XYH	1	6	SUF	51	73
XIJ	2	8	KUL	52	34
XYV	3	7	CYL	53	27
QOJ	4	10	KOS	54	44
XEG	5	7	TUS	55	64
QYH	6	9	PEB	56	64
NYJ	7	13	TYC	57	17
TYJ	8	9	DYL	58	24
XEC	9	6	LIR	59	39
QAZ	10	22	FYT	60	28

Table 7.2. (cont.)

CVC	Archer	Gr. 4-6	CVC	Archer	Gr. 4-6
XIM	11	16	GAN	61	77
TYV	12	17	TUR	62	51
WOJ	13	13	WOL	63	65
FEP	14	44	KYT	64	25
SIJ	14	19	LOD	65	72
DYJ	16	12	LUN	66	58
MIV	17	20	HUK	67	54
GEC	17	24	PES	68	72
VOB	19	41	SAF	69	66
PYM	20	23	LOF	70	74
WUB	21	42	CER	71	68
VAF	22	23	LAV	72	64
QYM	23	25	GYN	73	75
QAP	24	25	PAG	74	77
KEB	25	39	DOB	75	67
VUR	26	34	BIF	76	46
YUD	27	36	KUS	77	60
ZOT	28	49	MOV	78	78
KEZ	29	35	TER	79	72
KIG	30	60	NEV	80	53
HYN	31	45	COF	81	70
TAZ	32	56	GON	82	79
WYK	33	19	WAM	83	80
ZUP	34	41	PEK	84	74
JID	35	53	TAL	85	77
CUX	36	51	REB	86	74
HYZ	37	18	ROS	87	87
DAQ	38	17	HIK	88	53
NEZ	39	31	MUF	89	78
PEX	40	43	HEX	90	55
NEM	41	42	HOM	91	78
FIP	42	72	DOR	92	81
SYB	43	28	PIL	93	84
QAM	44	26	REP	94	66
QIC	45	39	JAZ	95	83
YAT	46	51	NAB	96	82
LYX	47	16	YUM	97	81
HEJ	48	20	NAY	98	82
BYG	49	38	RUN	99	97
JIS	50	42	MEN	100	95
			Total $\bar{X}$	50.5	46.9
			SD	29.0	25.3
			N	216	763

The product-moment correlation between Archer's values and the grade 4-6 values was .84. For the 45 items in common between CVC-50 and CVC-100, the correlation was .97. Experiment 2 used a larger number of trigrams, a larger sample of children, and three grades instead of two. Thus, in two independent samples, good relationship was found between Archer's values and those from children.

E. Experiment 3

1. Introduction. One of the purposes of the associated research was to compare normal and deaf subjects on paired-associate tasks. Since many of the deaf subjects were expected to have very poor speech, the pronounceableness of CVC trigrams might be expected to work to the advantage of the normal children. A paired-associate study was designed in which the items were either pronounceable trigrams (CVC) or unpronounceable trigrams (CCC). In an effort to compare the meaningfulness of the two lists, it was decided to collect association values for the two kinds of material from the same subjects and under the same conditions.

2. Materials and Subjects. The six CVCs used as the nucleus of CVC-100 (Experiment 2) were also used in the development of the pronounceable items selected for this study. Six CCC trigrams were taken from Witmer's list in a way which minimized duplication of letters and with the restriction that the mean value for the six items be equal to the mean value for the six CVCs used, based on Archer's data. The final items selected were DWB, TCJ, NQS, PZK, RGW, and SJQ with Witmer's values of 17, 21, 21, 25, 25, and 25%, respective-

ly. These formed the nucleus for the CCC list.

Nineteen more items were selected from Witmer's data. Six CCCs with high values (two each at 92, 96, and 100%) were included. It was thought that three of these placed at the beginning of the list would "reassure" the children that CCCs can be meaningful. The remaining 13 CCCs were sampled from fairly equal intervals across the unused values. Then the companion CVC list was compiled selecting from the trigrams already drawn from Archer those which matched the selected CCCs in association value, being certain to include the CVCs selected for the paired-associate study. Since the CCC list had two items of 21% value, three of 25%, and two each of 92, 96, and 100%, an exact matching was not carried out. Rather than drawing more CVCs from Archer, it was decided to use those for which children's values were available and, therefore, the lists were matched as well as possible under the circumstances.

Two different random orders of the 25-CCC and of the 25-CVC items were prepared. The items were listed for evaluation by the subjects in three different ways. Initially, homogeneous columns were used to minimize contrast effects. Four different answer sheets were prepared to accomodate the two orders and to allow the CCC and the CVC lists to appear equally often as the first and second columns.

Later, additional data were collected to evaluate the contrast effects themselves. The two sets of trigrams were intermingled in the columns either alternately or randomly. One order was used for each manner of listing. Copies of all CCC-CVC answer sheets are included in Appendix C.

Altogether 612 children in grades 4-6 of the Detroit Public Schools participated in this portion of the study: 229 received the homogeneous lists (H), 190 the alternate lists (A), and 193 the random lists (R).

3. Results and Discussion. The association values obtained from the children along with the adult values for the same items are shown in Table 7.3. The three forms of presentation are indicated by H, A, and R for homogeneous, alternate, and random lists, respectively.

The data from the homogeneous listing of items (H) were obtained first and compared with the respective adult values. The product-moment correlation between Archer's values and those obtained for the CVCs was .87 and between Witmer's values and the CCCs was .88. The high-valued CCCs tended to be evaluated much lower by the subjects of this experiment than by their adult counterparts. This might be attributed, in part, to the use of three of these items (TWN, JMP, and DNT) at the beginning of the CCC-H list to facilitate the response set. However, items with equivalent values (SLW, LFT, and KNG) were distributed randomly within the list, and the values for these three suggest that position effect is not the entire explanation.

There appeared to be evidence in the H lists that the subjects evaluate each column according to its own criteria since the association values varied from 5-98% for CVCs and from 8-85% for CCCs. The effect of the transition from one type of material to the other was

Table 7.3. Association values for three forms of List CCC-CVC.

		Grades 4-6					Grades 4-6		
CVC	Archer	H	A	R	CCC	Witmer	H	A	R
QOJ	4	5	9	10	GQC	4	8	6	13
XEG	5	8	17	24	KBF	13	11	9	9
SIJ	14	18	29	33	DWB	17	13	20	12
GEC	17	26	23	32	TCJ	21	10	8	6
VAF	22	22	34	36	NQS	21	10	8	10
KEB	25	31	45	52	PZK	25	10	13	8
YUD	27	38	33	40	RGW	25	21	18	11
ZOT	28	40	48	53	SJQ	25	10	14	8
WYK	33	15	23	25	BMG	33	24	24	11
DAQ	38	10	26	22	HNW	38	15	10	11
FIP	42	77	75	74	CFN	42	10	14	20
QIC	45	35	46	63	PTL	45	30	26	15
JIS	50	34	40	64	BLP	50	34	25	33
KOS	54	36	31	54	WRZ	54	13	18	18
DYL	58	28	28	38	THZ	58	33	19	30
WOL	63	78	73	81	HPR	63	33	24	22
HUK	67	56	66	63	ZNG	67	36	34	38
CER	71	63	79	76	FNK	71	60	65	60
DOB	75	58	60	69	NCK	75	65	59	52
WAM	83	70	63	83	KNG	92	78	71	56
REB	86	80	64	82	JMP	92	54	61	54
MUF	89	77	86	86	LFT	96	85	79	71
DOR	92	86	89	91	TWN	96	68	58	68
NAB	96	78	76	82	SLW	100	54	35	38
MEN	100	98	100	99	DNT	100	41	35	45
$\bar{X}$	51.4	46.7	50.5	57.3	$\bar{X}$	52.9	33.0	30.1	28.8
SD	29.8	27.9	25.4	25.0	SD	30.8	24.0	22.1	21.1
N	216	229	190	193	N	25	229	190	193

only apparent on the association value of the initial item of the second column and more particularly when the second column comprised CVC trigrams. By chance, WOL was the initial CVC trigram in both orders. When the CVC column was to the left and WOL was the first item they were to evaluate, 68% of the subjects marked it "Yes".

However, when the CVC column was to the right and WOL became the first CVC to be judged following 25 CCCs, its association value rose to 88%. Examining the CVCs which appeared in the second position, there was no difference in association values according to whether the CVC column was judged first or second. Considering the initial CCC items, one (JMP) varied from 65% to 49% as the CCC column was presented first or last. However, the other (TWN) showed greater stability, changing from 69% when in the first column to 67% when following the CVC column.

The indication that the values for the two kinds of trigrams may not be related to one another was disturbing. If the two homogeneous lists were evaluated independently, then there is little basis for making comparisons across kinds of trigrams. In order to verify this assumption, the random and alternate listings of trigrams were administered. These values are also presented in Table 7.3. The intercorrelations among the three children's values are very high. Between H and A the correlation is .95; between H and R, r = .92; and between R and A, r = .95. On this basis, it was felt that the scale values for the two kinds of trigrams may be assumed to represent points along the same continuum.

An examination of the mean association values appearing at the bottom of Table 7.3 suggests that adult association values for CCCs are not numerically consistent with those obtained from children. The difference noted there for Form H is statistically reliable ($\underline{t}$ = 2.55; df = 48; p < .02). This difference is more likely due to the contrast effect from being evaluated with CVC trigrams rather than a function of the age difference between Witmer's subjects and the grade-school children used here. If this is the correct source of the variance, it implies that adult values for CCC trigrams as a whole are somewhat inflated as compared to adult CVC association values. Greater stability is obtained with the CVC trigrams since the differences between the mean association values from adults and children are not significant.

F. Experiment 4

1. Introduction. In tabulating the data from the previous experiments, it was noted that subjects tended to respond "Yes" to about half the items. Archer reported a similar finding (1960, p. 4). In order to determine whether this was a function of the fact that the trigrams covered the entire range of association values, it was decided to administer lists comprised of only half the range of values.

2. Materials and Subjects. The 100 trigrams used in Experiment 2 were divided into two lists on the basis of Archer's values; one list (CVC-L) contained the trigrams with association values from 1-50% and the other (CVC-U) had the 50 items from 51-100%. Archer's values were used to divide the list since the data for Experiment 2 had not then been analyzed. Furthermore, the correlation of .83 obtained in Experiment 1 gave confidence that the rank order of the trigrams would be relatively constant for adults and for children. Two random orders of each list were used. Copies appear in Appendix C.

A total of 632 subjects in grades 4-6 of the Detroit Public Schools were used in this experiment. The two orders of the two lists were distributed serially in each classroom so that 316 subjects from these grades evaluated CVC-L and the other 316 received CVC-U.

3. Results and Discussion. Table 7.4 presents the association

Table 7.4. Association values for Lists CVC-L and CVC-U, with values obtained from List CVC-100 shown in parentheses.

CVC-L							
CVC	Archer	4-6		CVC	Archer	4-6	
XYH	1	12	(6)	VUR	26	47	(34)
XIG	2	20	(8)	YUD	27	50	(36)
XYV	3	17	(7)	ZOT	28	62	(49)
QOJ	4	24	(10)	KEZ	29	40	(35)
XEG	5	19	(7)	KIG	30	80	(60)
QYH	6	16	(9)	HYN	31	47	(45)
NYJ	7	21	(13)	TAZ	32	69	(56)
TYJ	8	29	(9)	WYK	33	30	(19)
XEC	9	14	(6)	ZUP	34	64	(41)
QAZ	10	41	(22)	JID	35	69	(53)
XIM	11	32	(16)	CUX	36	67	(51)
TYV	12	37	(17)	HYZ	37	29	(18)
WOJ	13	40	(13)	DAQ	38	35	(17)
FEP	14	61	(44)	NEZ	39	52	(31)
SIJ	14	34	(19)	PEX	40	67	(43)
DYJ	16	24	(12)	NEM	41	64	(42)
MIV	17	33	(20)	FIP	42	83	(72)
GEC	17	37	(24)	SYB	43	41	(28)
VOB	19	61	(41)	QAM	44	49	(26)
PYM	20	50	(23)	QIC	45	35	(39)
WUB	21	54	(42)	YAT	46	70	(51)
VAF	22	32	(23)	LYX	47	35	(16)
QYM	23	43	(25)	HEJ	48	53	(20)
QAP	24	43	(25)	BYG	49	59	(38)
KEB	25	60	(39)	JIS	50	59	(42)
				$\overline{X}$	25.5	44.2	28.8
				SD	14.6	18.1	16.3
				N	216	316	763

Table 7.4. (cont.)

CVC-U							
CVC	Archer	4-6		CVC	Archer	4-6	
SUF	51	60	(73)	BIF	76	24	(46)
KUL	52	21	(34)	KUS	77	37	(60)
CYL	53	15	(27)	MOV	78	78	(78)
KOS	54	24	(44)	TER	79	56	(72)
TUS	55	41	(64)	NEV	80	46	(53)
PEB	56	48	(64)	COF	81	63	(70)
TYC	57	12	(17)	GON	82	64	(79)
DYL	58	19	(24)	WAM	83	69	(80)
LIR	59	23	(39)	PEK	84	63	(74)
FYT	60	21	(28)	TAL	85	71	(77)
GAN	61	67	(77)	REB	86	63	(74)
TUR	62	48	(51)	ROS	87	82	(87)
WOL	63	69	(65)	HIK	88	49	(53)
KYT	64	22	(25)	MUF	89	64	(78)
LOD	65	50	(72)	HEX	90	34	(55)
LUN	66	39	(58)	HOM	91	77	(78)
HUK	67	45	(54)	DOR	92	73	(81)
PES	68	46	(72)	PIL	93	76	(84)
SAF	69	66	(66)	REP	94	47	(66)
LOF	70	64	(74)	JAZ	95	75	(83)
CER	71	55	(68)	NAB	96	56	(82)
LAV	72	44	(64)	YUM	97	76	(81)
GYN	73	60	(75)	NAY	98	74	(82)
PAG	74	72	(77)	RUN	99	97	(97)
DOB	75	49	(67)	MEN	100	99	(95)
				$\bar{X}$	75.5	53.9	64.9
				SD	14.6	21.2	19.0
				N	216	316	763

values from Archer, from the two lists, and from Experiment 2 where the 100 trigrams were evaluated in a single list. Again the ranking of the items within a list remained constant; the correlation between the scores on CVC-L, or CVC-U, with the corresponding items on CVC-100, was .93 in both cases. However, the absolute values changed markedly.

The association values for CVC-L ranged from 12-83%, while CVC-U values varied from 12 to 99%. The mean number of "Yes" responses given by the subjects receiving the CVC-L lists was compared with those for the CVC-U lists. The CVC-L list yielded a mean of 44.2% while the mean for CVC-U was 53.9%. These means differed significantly ($z = 2.42$; $p < .05$) indicating that the material within a list does have an influence.

However, there also appears to be an important response-set effect since the means of the "Yes" responses of the 1-50% and 51-100% trigrams had been 28.8 and 64.9%, when part of a list of 100, as contrasted with 44.2 and 53.9%. The values obtained in Experiment 2 (CVC-100) and the values under the restrictions of CVC-L and CVC-U are presented side by side in Table 7.4. Comparisons of the individual scores as well as the means and standard deviations demonstrate the effect of the list upon the responses. Differences between the mean values obtained by Archer and in the present study using CVC-L and CVC-U were significant ($z = 5.67$ and 5.84, respectively). When the means of the children's values on the truncated lists were compared with the results using CVC-100, again significant differences were found ($z = 4.53$ for CVC-L and $z = 2.75$ for CVC-U). Of the 50 items making up CVC-L, all except one (QIC) are rated higher in the list with the restricted range than in the list with the full range. Conversely, of the 50 items on CVC-U, 45 are rated lower on the list with the restricted range, three are given the same rating, and two are rated higher. There is some spreading of the distribution as well as a shifting of the means. The standard deviations are both about two units larger than the corresponding standard deviations for the parts of the total list.

The fact that both restricted lists yielded association values of about the same range, coupled with the finding that the proportion of positive responses per list was reasonably close to .50 in all cases, resulted in a further examination of these data. Regression coefficients for the correlations between the restricted lists and the corresponding CVC-100 items were calculated. The coefficient of regression for CVC-L on CVC-100 was 1.03 while that for CVC-U on CVC-100 was 1.04. The slopes of the two lines are nearly identical suggesting that the items within the subtests retained their original order. The increases in the ranges indicate greater separation of the individual items, and the shift in the average values points to a probable trend to center at the 50% level; i.e., respond "Yes" to half of the trigrams being evaluated.

The results of this experiment strongly suggest that the criterion used in evaluation of a list of trigrams represents some central tendency of the pool of items with individual trigrams then being compared to this standard, consistent with Helson's adaptation-level theory (1959). However, it must be kept in mind that this phenomenon may also reflect the subjective probability of the distribution of dichotomous events in an ambiguous situation.

G. Experiment 5

1. Introduction. The CCC-CVC list used in Experiment 3 had

been generated to obtain association values for a learning study. It was decided to attempt to assess the effect of prior exposure upon association values.

During the learning task, each of the six trigrams (CCCs or CVCs) were presented as response items for a total of 10 times. Since these trigrams were of low association value, it can be assumed that the subjects probably began at a very low level of familiarity with the items. As the task progressed, the items should have increased in familiarity, and the subjects might also have "found" some association which would aid them in the performance of the task. At any rate, it seemed reasonable to expect the association values for these particular items to be higher than values obtained from a comparable group having no previous exposure to the trigrams.

2. Materials and Subjects. Form H of the CCC-CVC list, as described in Experiment 3, was presented following the administration of a paired-associate learning task in which six of the trigrams were response members of the pairs.

A total of 386 subjects from grades 4-6 in the Detroit Public Schools were used. Of these, 126 subjects had a learning task in which CCCs were responses; the remaining 260 had CVC responses. The subjects were not forewarned about the collection of association values following the learning task.

3. Results and Discussion. The results of the experiment are presented in Table 7.5. The trigrams are again presented according to Witmer's or Archer's values as in Table 7.3. "Control" refers to

Table 7.5. Association values for experimental and control groups using List CCC-CVC.

CCC	Control	E-CCC	E-CVC	CVC	Control	E-CCC	E-CVC
GQC	8	11	9	QOJ	5	11	6
KBF	11	17	22	XEG	8	8	8
DWB[a]	13	15	20	SIJ[a]	18	11	32
TCJ[a]	10	18	16	GEC[a]	26	19	37
NQS[a]	10	12	18	VAF[a]	22	21	32
PZK[a]	10	25	15	KEB[a]	31	29	45
RGW[a]	21	23	17	YUD[a]	38	28	43
SJQ[a]	10	15	18	ZOT[a]	40	39	57
BMG	24	26	26	WYK	15	22	20
HNW	15	15	13	DAQ	10	13	11
CFN	10	15	13	FIP	77	76	68
PTL	30	27	31	QIC	35	22	23
BLP	34	26	31	JIS	34	27	34
WRZ	13	22	19	KOS	36	21	27
THZ	33	23	30	DYL	28	20	23
HPR	33	17	23	WOL	78	80	75
ZNG	36	34	40	HUK	56	47	50
FNK	60	62	61	CER	63	42	55
NCK	65	64	67	DOB	58	51	60
KNG	78	70	76	WAM	70	68	63
JMP	54	61	56	REB	80	56	70
LFT	85	85	78	MUF	77	66	67
TWN	68	67	58	DOR	86	79	84
SLW	54	55	58	NAB	78	60	79
DNT	41	30	35	MEN	98	94	96
$\overline{X}$	33.0	33.4	34.0	$\overline{X}$	46.7	40.4	46.6
SD	24.0	22.2	21.4	SD	27.9	25.6	25.0
N	229	126	260	N	229	126	260

[a] Items used in learning study.

the values obtained in Experiment 3 from children in grades 4-6 using CCC-CVC, Form H, with no prior exposure. The two experimental groups were the subjects from this experiment who had the learning task prior to evaluating the trigrams; E-CCC refers to the group who received the CCC trigrams and E-CVC refers to the subjects who learned

CVCs during the preceding task.

The correlations between the sets of data for the CCC and for the CVC trigrams indicate that the three groups responded similarly to the items. For the CCC material, E-CCC and Control correlated .96, E-CVC and Control = .98, and E-CCC and E-CVC = .97. Considering the CVC items, the values were of the same magnitude, E-CVC and Control = .96, E-CCC and Control = .96, and E-CCC and E-CVC = .94. These findings emphasize the fact that the relative positions of the trigrams remain constant in spite of attempts to introduce variation.

Comparing the values obtained for the CCC trigrams from the three groups of subjects, it is apparent that prior exposure had little systematic effect. The difference in the percentage of "Yes" responses to the CCCs varies randomly among the three conditions compared. On the other hand, the values for the CVCs for the prior-exposure group were greater than the Control on 10 trigrams, six of which were the specific items used in the learning task. Since the group who learned the CCC trigrams did not show the same change in their rating of the CVC items, it appears that prior exposure to the specific material is the critical factor, not merely exposure to trigrams in general.

A chi-square test of the number of subjects who responded "Yes" in the Control group and in the relevant experimental group (Table 7.5) for each item was performed. These chi-square values, reported in Table 7.6, show that exposure to CVCs via the learning task resulted in more significant changes in the subsequent association value of the item than does equivalent exposure using CCC trigrams.

Table 7.6. Chi-square values for number of "Yes" responses in control and relevant experimental groups. (Items used in learning task are set off by double spacing.)

CCC	X^2		CVC	X^2	
GQC	1.22		QOJ	.98	
KBF	2.93		XEG	.01	
DWB	.41		SIJ	13.04**	E>C
TCJ	4.86*	E>C	GEC	6.89**	E>C
NQS	.81		VAF	7.18**	E>C
PZK	13.61**	E>C	KEB	11.17**	E>C
RGW	.38		YUD	1.27	
SJQ	2.59		ZOT	15.70**	E>C
BMG	.13		WYK	2.46	
HNW	.02		DAQ	.68	
CFN	2.15		FIP	4.39*	C>E
PTL	.14		QIC	8.38**	C>E
BLP	1.67		JIS	.05	
WRZ	4.78*	E>C	KOS	4.51*	C>E
THZ	3.12		DYL	1.07	
HPR	.29		WOL	.39	
ZNG	.10		HUK	1.73	
FNK	.24		CER	3.17	
NCK	.02		DOB	.27	
KNG	2.19		WAM	2.24	
JMP	1.41		REB	6.46*	C>E
LFT	.02		MUF	6.02*	C>E
TWN	.04		DOR	.18	
SLW	.06		NAB	.26	
DNT	4.45*	C>E	MEN	.38	

** $p < .01$.
* $p < .05$.

There were 10 CVC trigrams in which there were changes significant at the .05 level. Of these, five were responded to more positively by the experimental group, and all five of these were trigrams used in the learning task. The finding that five items not previously seen were evaluated lower by the experimental group than by the control group suggests that the learning task had both positive and negative effects upon the judgments. From the results of Experiment 4, it would be expected that an increased number of "Yes" responses to the familiarized items should result in a decreased number of "Yes" responses elsewhere in the list; however, it does not explain why they were applied to certain trigrams frequently enough to reach significance.

Examining the CCC material from Table 7.6, only four items were reacted to differently by the experimental and control groups as measured by the chi-square test of significance. Three of these trigrams were rated positively by more of the experimental group than the control, and two of these three were items from the learning task.

The differential effect of prior experience with the two kinds of trigrams parallels the difference in performance on the learning task, the group learning the CCC items being significantly poorer than the group using CVCs. Perhaps if the two groups had been equated as to performance rather than for number of exposures, the association values for the two kinds of trigrams may have been affected similarly.

H. Summary and Conclusions

The series of experiments described here indicate that both normal and hearing-handicapped children produce reliable results when asked to judge trigrams as "meaningful". Furthermore, the high correlations obtained between the values for children and for adults suggest that the two groups are using the same or similar criteria in performing the task. The fact that children and adults agree on the relative meaningfulness of trigrams may be a function of language itself. The language experience of children differs from that of adults in degree but not in kind. Palermo et al., (1964) make such a suggestion and postulate that association values indicate the degree of departure of the trigram from the parent language.

However, the evidence gathered suggests that the proportion of subjects who respond positively to a trigram is also a function of the pool of such trigrams being evaluated. This was particularly apparent in Experiment 4 where the two restricted lists were evaluated very similarly. The argument that this result is an artifact of the experimental procedure whereby the trigrams were available to the subjects simultaneously seems to be refuted by Archer's report that successive presentations of the trigrams produced a similar effect. A more tenable explanation may be that the required dichotomous evaluation leads the subjects to the hypothesis that the items should be evenly distributed between the two categories.

One of the important findings of the study was the relatively high correlation from condition to condition among the children utilized. This, of course, attests to the consistency with which the items were put in a given rank order rather than the absolute values derived from the number of children who responded "Yes" or "No". Six CVC trigrams, originally selected for a learning experiment, appeared on five different lists and were thereby presented to five independent samples of children (total N = 1694) in the fourth to sixth grades. Table 7.7 presents Archer's values for the six trigrams and the five separate values obtained in the present experiment, along with the rank order associated with each of the six separate rating scales. The average of the association values from the children varied from a low of 26.1% to a high of 45.8%; all of the average values from the children were higher than Archer's average of 22.2%. The highest scores were achieved when the syllables appeared as part of the restricted list encompassing Archer's association values of 1 to 50% (CVC-L). However, the most interesting result of this tabulation is the consistency with which these nonsense syllables were ranked. All five groups rated ZOT as the most meaningful. While other syllables were not ranked with the same absolute consistency, there actually is very little variation from sample to sample. These results are so consistent that one is

Table 7.7. Ratings on six trigrams which appeared on five separate lists.

	Archer		CVC-100		CCC-CVC		CVC-L		E-CVC		E-CCC	
CVC	%	R	%	R	%	R	%	R	%	R	%	R
SIJ	14	1	19	1	18	1	34	2	32	1.5	11	1
GEC	17	2	24	3	26	3	37	3	37	3	19	2
VAF	22	3	23	2	22	2	32	1	32	1.5	21	3
KEB	26	4	39	5	31	4	60	5	45	5	29	5
YUD	27	5	36	4	38	5	50	4	43	4	28	4
ZOT	28	6	49	6	40	6	62	6	57	6	39	6
$\bar{X}$	22.2		31.7		29.2		45.8		41.0		26.1	
N	216		763		229		316		260		126	

tempted to suggest that KEB and YUD, as well as GEC and VAF, are out of order when Archer's values are applied to children.

Out of the study grows the conclusion that, at least as far as children are concerned, the association values are closely related to the conditions under which the values are derived and have little meaning as absolute scores. Underwood and Schulz (1960) had warned against using meaningfulness values in an absolute sense in discussing adult norms from various sources. On the other hand, it appears that one can accept with considerable confidence the relative position or rank order of a set of trigrams. Quite consistently and clearly the three trigrams, SIJ, GEC, and VAF, appear less meaningful to children than do the trigrams, KEB, YUD, and ZOT. If one keeps these facts in mind, the tabled values of Glaze, Archer, and Noble should all be useful in generating material for children.

Our experiment with the combined CCC-CVC list adds information on the relationship of association values for CCC and CVC trigrams. Clearly one cannot assume equivalence between the two types of trigrams simply because the values from Witmer are numerically equal to the values from one of the other sources. In one of our learning studies, a list of six CCC trigrams was selected with an average value of 22.3 from Witmer and a list of six CVC trigrams was selected with an average value of 22.2 from Archer. In Experiment 3, reported here, the average value obtained for the CVCs was 29.2 while the average value for the CCCs was only 12.3 using the H form. In Experiment 5, where the association values were obtained after the relevant trigrams had been used in the paired-associate learning task, the average value for the CVCs was 41.0, and for the CCCs it was 18.0. It is not clear whether college students will perform similarly. Actually, it is possible that the values are more comparable than our data would suggest, but that children are bound by some rigid rule such that nothing can be a "word" that does not have a vowel. Some of our other experiments suggest that children approach tasks of this kind with a good deal of rigidity.

RESULTS PERTAINING TO MEANINGFULNESS

The establishment of association values for consonant-vowel-consonant trigrams, as described in Experiment VII, was critical to the remaining series of experiments. In most contexts, the associability of the material to be learned contributes significantly to performance. Having reliable estimates of the association values of materials, the experiments of this chapter were designed to explore the ramifications of meaningfulness and its *a priori* correlates, association value, pronounceableness, and similarity.

The first investigation of the series, Experiment VIII, concerned itself with attempts to establish meaningfulness in previously low meaningful material. While not a direct investigation of the parameters mentioned above, a paradigm was utilized which was deemed analogous to the normal way in which meaningfulness comes to be attached to nonmeaningful material. Interest was then turned to the confirmation of previously reported correlations between association value and performance. The results of this investigation are reported in Experiment IX. Experiment X examined a second parameter of performance, pronounceableness. Continuing in the same context, the last of the *a priori* measures, similarity, was varied in Experiment XI.

As will be seen, the results of Experiments VIII through X were unrewarding. Performance was not altered in the anticipated fashion. This led to the exploration of alternative parameters of learning.

Experiment VIII

Production of Meaningfulness by Association

ABSTRACT. Performance on the second of two paired-associate tasks, sequentially administered to groups of subjects, was used as an index to assess the degree of facilitation produced by associating a low meaningful item to a high meaningful item during the first task. By making responses available and switching S-R to R-S configurations for different groups in the first task, the design also provided information concerning possible differential effects of stimulus versus response meaningfulness when considered from the first task, and A-B, A-C versus B-A, A-C transfer when considered from performance on the second task. Results suggest that meaningfulness may be produced by association in that it can overcome expected negative transfer effects, especially if the initial low meaningful component is also a verbal component. In addition, results cast doubt on the "stimulus" versus "response" distinction in paired-associate learning except as descriptive labels for spatial-temporal operations, while upholding the facilitative effects of the total degree of meaningfulness within item pairs.

A. Introduction

Underwood and Schulz (1960) have amassed considerable data investigating the link between meaningfulness, or more properly their construct "M", and frequency of written occurrence. Most of the information gained in this research concerned the response availability stage, the first stage, of the hypothesized two-stage learning process. The present paper will attempt to supply information about the role of association, the second stage, in the learning process. It was hoped that meaningfulness of a low meaningful stimulus could be increased through the association of a meaningful word with the low meaningful stimulus. It should be pointed out that a specific attempt to provide a mediating response was not involved. Rather, the association with a more meaningful item was thought to directly increase the meaningfulness of the stimulus.

An A-B, A-C paradigm was used in which the response member of the paired-associate list in the first learning task was varied in meaningfulness for independent groups. One component of each S-R pair contained a meaningful word, while the other component was either a low meaningful line configuration (modified electrical symbol) or a CVC trigram. The meaningful word was not always the response component of this first learning task because the strength of backward associations was also of interest in this study. Thus, a B-A, A-C paradigm was also used. The second learning task involved the learning of a single-letter response to a stimulus which was previously one component of the first learning task.

Underwood and Schulz (1960) have made a strong case for the dominance of response learning as compared to the associative phase in the production of paired-associate learning scores. Since the primary focus of the present study was upon the associative or second stage of learning, it was deemed necessary to eliminate the differential effects of Stage 1 or response learning. In the first learning task, the A-B of the learning paradigm, differences due to response learning were avoided by having response availability; in all cases, the responses appeared at the top of the answer page with adjacent numbers and the subject responded by writing down the number which was beside the appropriate response. In the second task, the A-C portion of the learning paradigm, the set of responses did not appear on the answer sheet. This was not considered necessary for two reasons. First, it was assumed that the single-letter responses were all highly available, and, secondly, the same responses were used in all conditions thereby eliminating any differences due to the use of different sets of responses.

B. Experimental Procedures

1. Subjects. Subjects were 512 sixth-grade students from the Detroit Public Schools tested in classroom groups.

2. Materials. The V_1, V_2, and V_3 materials, described in the chapter devoted to apparatus, et cetera, were used, along with the responses indicated there. The S-R pairings are in the same rows in Table 1 of that chapter.

3. Procedure. A recall form of the standard paired-associate learning paradigm was used for both learning tasks. Alternate learning trials, where both stimulus and response were presented, and test trials, where only the stimulus was presented, were used for a total of eight sets of trials in each phase of the learning study. The two learning tasks were administered successively, with only time for instructions allowed between tasks. The entire testing session took about 45 minutes.

The material was presented visually on a screen by a slide projector which was advanced automatically by a tape recorder (Ampex-Bell & Howell system). In the A-B segment of the study, the stimuli and responses were presented successively for 3 sec each during the learning trials, with an inter-pair interval of about 5 sec. The inter-trial interval was 15 sec. During the test trials, the stimulus was presented for 3 sec, and a 4 sec inter-stimulus interval was allowed for the recording of the responses. As mentioned previously, the responses for this phase of the study were listed at the top of the answer page to avoid differences due to response availability. Each response had a number adjacent to it and the subjects were instructed to write this number down in the appropriate space on the answer sheet. Three orders of responses and adjacent numbers were provided on different trials so that both the spatial location and the number-response combination varied with successive trials.

For the second portion of the study, the A-C learning task, a similar procedure was followed. During the learning trials, the stimuli and responses were presented successively for 2.5 sec each, with a 5.5 sec inter-pair interval. During a test trial, the stimulus was presented for 2.5 sec with a 5.5 sec inter-item interval to allow time for responding. In this segment of the study, responses were not listed at the top of the answer page.

Three different orders of items in the learning and test trials were used in both portions of this study.

C. Results and Discussion

Table 8.1 presents the mean correct responses, standard deviations, and sample sizes for the two learning tasks. These data will be discussed in two parts: (1) results relating to Task I (A-B), and (2) results relating to Task II (A-C).

It will be noted that the "A" and "B" of any condition are

Table 8.1. Means and standard deviations of the number of correct responses, by conditions for the two learning tasks.

	Learning Tasks			$\bar{X}$	SD	$\bar{X}$	SD
Cond.	I	II	N	I	I	II	II
1A	V_1-V_3	V_1-X	64	36.2	9.4	33.6	15.5
1B	V_1-V_3	V_3-X	32	33.8	10.4	34.6	13.8
2A	V_3-V_1	V_3-X	31	36.3	9.7	37.3	9.7
2B	V_3-V_1	V_1-X	72	38.2	9.2	29.3	12.1
3A	V_2-V_3	V_2-X	61	28.2	10.2	29.7	13.0
3B	V_2-V_3	V_3-X	27	30.0	9.6	39.3	7.6
4A	V_3-V_2	V_3-X	20	23.0	12.0	33.1	12.7
4B	V_3-V_2	V_2-X	55	26.1	10.6	28.3	12.9
C1	V_1-V_3	V_2-X	57	33.2	7.7	27.9	10.3
C2	V_3-V_1	V_2-X	30	34.0	11.2	29.2	12.2
C3	V_2-V_3	V_1-X	29	24.9	11.9	35.4	9.1
C4	V_3-V_2	V_1-X	34	30.5	10.8	36.5	8.8

equivalent in the first learning task. No significant differences were expected or found. Thus, in the examination of the first of the two tasks, "A" and "B" conditions were pooled. The results of the pooling are presented in Table 8.2. The pooling leaves four experimental conditions whose differences are in the order of materials; i.e., "1" is different from "2" in that V_1 is the stimulus set in the first case and the response set in the second. In examining the effect of stimulus-response versus response-stimulus, the critical comparisons are "1" versus "2" and "3" versus "4". The comparisons were not significant, using _t_ tests. This finding would seem to

Table 8.2. Means and standard deviations of the number of correct responses with "A" and "B" groups pooled in each condition.

Conditions	N	$\overline{X}$	SD	t
1	96	35.29	9.82	1.64
2	103	37.59	9.30	
3	88	28.77	9.98	2.14
4	75	25.28	10.98	

support the work of Underwood and Schulz (1960) concerning the minimal role of "M" on the stimulus side and a sharply reduced role of "M" on the response side when responses are made available. These findings of no difference are also in agreement with the "easy recognition" task of Epstein and Streib (1962) in which paralogs of differing m value were used to construct L-H and H-L lists.

The present data seem to indicate that, given response availability, learning is a function of the total degree of "M" irrespective of the configuration of the elements as to stimulus or response placement of the highly meaningful component. This conclusion is obtained by examining the levels of performance for the two kinds of material used. A significant difference is found between the mean for Conditions 1 and 2 pooled and the mean for Conditions 3 and 4 pooled ($t = 8.39$; $p < .001$). The direction of this difference is consistent with previous data (Gaeth, 1963) which found V_2 material more difficult than V_1 material when single-letter responses were required, possibly indicating that the V_2 material is less meaningful than the V_1 material.

The comparison of each condition with the conditions which serve as controls for the effect of Task I on Task II serve as an additional indication of the reliability of the Task I data reported in Table 8.2. Thus, Condition 1 is compared to C1 for Task I, et cetera. None of the four comparisons reach statistical significance ($p < .01$), adding credence to the reliability of these data.

Inspection of Table 8.1 does not allow any simple evaluation of the effect of the first learning task upon the second learning task due to the existence of significant differences in Task I means as already noted. An analysis of covariance was done on the data in Table 8.1 in an attempt to evaluate the relative gains or losses in the second task attributable to the first task. Table 8.3 summarizes the analysis of covariance on these data. Not all comparisons between pairs of adjusted means would be meaningful. Certain comparisons will be selected for discussion and reasons for such comparisons given.

The effect of S-R versus R-S item relationships in the first task upon Task II performance can be evaluated by comparing Conditions 1A with 2B and Conditions 3A with 4B. In both of these comparisons, Task II is identical while the S-R pairings in Task I are reversed. The differences in the adjusted means for either of these comparisons are not significant. This would seem to indicate that meaningfulness has similar effects on learning and transfer independent of the "S" or "R" placement of the meaningful component. In

Table 8.3. Summary of the analysis of covariance for all conditions.

	Learning Tasks				Deviations from b		
Source	I	II	df	$b^{\#}$	df	Mean Square	Adjusted Mean
1A	V_1-V_3	V_1-X	63	.741	62	120.7	30.9
1B	V_1-V_3	V_3-X	31	.943	30	96.7	33.8
2A	V_3-V_1	V_3-X	30	.476	29	75.7	34.5
2B	V_3-V_1	V_1-X	71	.827	70	91.4	25.4
3A	V_2-V_3	V_2-X	60	.638	59	127.8	32.0
3B	V_2-V_3	V_3-X	26	.442	25	41.7	40.6
4A	V_3-V_2	V_3-X	19	.707	18	94.9	38.8
4B	V_3-V_2	V_2-X	54	.568	53	131.6	32.0
C1	V_1-V_3	V_2-X	56	.509	55	92.1	27.1
C2	V_3-V_1	V_2-X	29	.895	28	46.6	27.9
C3	V_2-V_3	V_1-X	28	.431	27	63.3	40.0
C4	V_3-V_2	V_1-X	33	.292	32	68.7	37.4
Within					488	95.3	
Reg. Coef.					11	160.1	
Common			500	.635	499	96.8	
Adj. Means					11	849.8	
Total			511		510		

[#] Regression coefficient.

terms of transfer paradigms, this would seem to indicate that (given response availability) A-B, A-C is equivalent to B-A, A-C. A similar interpretation can be made by the comparison of Conditions 1B versus 2A and 3B versus 4A. Again, only the "S" and "R" item positions are reversed in the first learning task, and again, no significant differences in adjusted means were found.

The crucial question becomes whether or not any transfer did in fact occur, or is Task II facilitation a function of practice effects. Control conditions were used in which the stimulus component of Task II did not appear in Task I. This type of control allows assessment of the effects of practice. It should also be pointed out that the control conditions are of the A-B, D-C type transfer paradigm which can serve as a base rate for the assessment of other transfer effects. Performance on the control conditions which reverse "S" and "R" placement in the first task are not different (C1 versus C2 and C3 versus C4), lending support to the reliability of these data as adequate for the assessment of practice effects.

Since the experimental conditions were of the A-B, A-C variety, one might expect the facilitation produced by having a highly meaningful component for the "B" term to be offset by the negative transfer effects known to occur in this paradigm (Postman, 1962b). The critical comparisons in this regard yield conflicting results. When Condition 1A is compared to its control C3 (or C4), it appears that negative transfer effects dominate over any possible increment of meaningfulness. The adjusted mean for Condition 1A is 30.9 and for C3 the value is 40.0. This difference is not significant, even at the .05 level (t = 1.89). However, the adjusted mean for Condition 3A is higher than its control C1 (the values being 32.0 and 27.1, respectively). Again, this difference is not significant (t = 1.52) but it is a strong reversal. If the directions of these differences were reliable, they would seem to indicate that meaningfulness is more easily induced in nonsense syllables (3A) than in nonmeaningful lines (1A). This seems to fit our conception of verbal material as approximating words and being more amenable to the attribution of meaningfulness than nonsense line configurations. However, the evidence for this is quite indirect and not supported by statistically significant comparisons.

That the two-stage learning task was partly successful in producing meaningfulness by association is also indirectly supported by the fact that the negative transfer paradigm used in the experimental conditions failed to produce significant decrements in performance when compared to the control conditions. A design in which the A-B, A-C paradigm was used with all low meaningful components would be of use in establishing a base line for the assessment of the production of meaningfulness by association. Merikle and Battig (1963) present evidence relative to this aspect of the problem. Using an A-B, A-C paradigm, they reported zero to negative transfer (although not significantly so) as the paired-associate material increased in meaningfulness with the zero transfer obtained from CCC trigrams.

D. Summary and Conclusions

A design in which the effects of associating a highly meaningful component with a component low in meaningfulness could be assessed by performance on a second paired-associate task was used in an attempt to explore the possibility that meaningfulness could be produced by association. Performance on the second task, in which the low meaningful component of the first task served as a stimulus, was compared to conditions which controlled for the possible facilitative effects of practice. At the same time, these control conditions provided a base rate against which to evaluate transfer effects. That is, the control conditions were of the A-B, D-C type, while the experimental conditions took the form of an A-B, A-C transfer paradigm. Since the A-B, A-C paradigm is known to result in negative transfer, any obtained facilitation as a result of the association with a highly meaningful item must be great enough to offset negative transfer effects. The design also touched on the question of the meaning of "stimulus" versus "response" distinctions except as descriptive labels for spatial and temporal operations by providing the "response availability" stressed by Underwood and comparing performance under A-B, A-C, and B-A, A-C conditions.

Results suggest that the expected debilitating effects of the negative transfer situation were partially overcome by facilitation produced by the association of a highly meaningful item. Further, these results suggest that such a performance increment occurs to the largest extent when the component to be facilitated is of a verbal nature in the sense that it can be readily pronounced and used as a coherent label. Thus, nonsense syllables but not nonsense lines appeared to overcome the negative transfer effects when associated with a meaningful component. These findings must be considered tentative pending more clear-cut statistical findings and the establishment of a better transfer base line through a paradigm which contains all low meaningful components.

In addition, the findings cast doubt on the scientific utility of distinguishing between "stimulus" and "response" terms except as descriptive terms for spatial-temporal operations. The A-B, A-C paradigm was in no case superior to the B-A, A-C paradigm with identical material, while total degree of meaningfulness within a pair, independent of "stimulus" or "response" position, made a significant difference. Since the configuration of the item pair did not make a difference given response availability, indirect support for the notion of a response learning phase (Underwood and Schulz, 1960) is provided. However, the second associative phase must also have occurred during learning, and here too, the configuration of the item pair did not make a difference, even though the two items differed largely in meaningfulness. It would seem then that if the terms "stimulus" and "response" have any theoretical meaning, they should be restricted in usage to the response learning phase.

Experiment IX

Association Value, Meaningfulness, and Learning

ABSTRACT. Independent groups of children in the fourth, fifth, and sixth grades were tested with seven paired-associate tasks. Each task was homogeneous with respect to association values of 19.8, 30.6, 40.0, 50.6, 60.6, 70.0, and 80.6. A test for simple effects across lists indicates that association value differences of as large as 60.8 are needed to significantly alter performance. This finding is interpreted as indicating that the portion of performance variance attributable to association value is much less than would be inferred from previous experimentation.

A. Introduction

Experiment VII was conducted to fill the gap in normative data for association value of CVC and CCC trigrams in children. By the same token, no systematic investigation has been uncovered which deals with the relationship between association value of materials and learning performance with children as subjects. The purpose, then, of this experiment, is to establish normative data on such a relationship.

Studies with adult subjects have concluded that performance is directly related to association value (Underwood and Schulz, 1960). In general, this conclusion has been based upon studies which used materials which are heterogeneous in terms of association value. By this is meant that within-list variability of association values was high; i.e., performance of an item with low association value was compared to performance with an item of high association value in the same list. At best, categories of association value have been restricted to gross groupings such as "low", "medium", and "high". Estimates of the amount of association value change for significant changes in performance have not been made.

The experiment at hand attempts to systematically investigate performance for a wide range of association values while, at the same time, attempting to reduce intralist association value variability. It is felt that the reduction of this type of variation is essential to more concise estimates of the effect of association values on performance. High intralist variability essentially provides the subjects with "easy" and "difficult" items within a list (given that performance is a function of association value) and biases performance in the direction of accenting the effects of association value. In Experiment III, Phase 1, an indication was found that children do tend to learn the easier items first. Thus, the trigram PIL would be relatively easier in a list with SIJ than it would be in a list with JAZ. The use of a number of homogeneous lists sampling from different points along the dimension of association value will allow, through the use of post mortem tests, estimates of the changes in association value needed for significant changes in performance. As a further control, independent subjects from the same student population were used as estimators of the association value of the trigrams used in the present experiment (see Experiment VII).

B. Experimental Procedures

1. Materials. Seven lists of five S-R pairs were constructed.

Each list defined a different condition. Stimulus materials did not vary, in all cases consisting of the Arabic numerals 4-8. Responses were nonsense syllables selected from the fourth- to sixth-grade norms for 100 CVCs as reported in Experiment VII. There, the values showed high reliability as indicated by test-retest and by replication measures. The seven lists used CVCs which were drawn from successive 10% ranges beginning with 6% and ending at 85% association value. Table 9.1 presents these lists of response items and gives the fourth- to sixth-grade association value for each trigram. Letter duplication within a list was minimized. Each list had one vowel duplication with the exception of that used in Condition 5 in which the letter "L" is duplicated.

Table 9.1. Stimulus-response (S-R) pairings for the seven conditions with association values (AV) from grades 4-6.

	Conditions													
	1		2		3		4		5		6		7	
S	R	AV	R	AV	R	AV	R	AV	R	AV	R	AV	R	AV
4	LYX	16	QAM	26	BYG	36	BIF	46	TAZ	56	SAF	66	GAN	77
5	DAQ	17	FYT	28	QIC	39	ZOT	49	LUN	58	DOB	67	MUF	78
6	SIJ	19	NEZ	31	LIR	39	CUX	51	KIG	60	CER	68	DOR	81
7	VAF	23	VUR	34	NEM	42	NEV	53	PEB	64	PEK	74	JAZ	83
8	GEC	24	KUL	34	KOS	44	HUK	54	WOL	65	GYN	75	PIL	84
$\bar{X}$		19.8		30.6		40.0		50.6		60.6		70.0		80.6

2. Subjects. A total of 1169 subjects from the fourth, fifth, and sixth grades of the Archdiocese of Detroit School System was

tested.

3. Procedure. The paired-associate lists were presented visually on a screen, projected from a Tel-n-See machine. Alternate learning and test trials were given for 10 trials. During learning trials, the stimulus appeared for 2.5 sec immediately followed by the response for 2.5 sec. The inter-pair interval was 2.5 sec. During test trials the stimulus appeared for 2.5 sec with 6 sec allowed to write the response in test booklets.

C. Results and Discussion

The mean correct responses, standard deviations, and sample sizes for each condition are presented in Table 9.2. As is illustrated in Figure 9.1 (p. 138), the means across conditions, for each grade, are relatively stable with slightly increasing performance with increasing association value for the list. It should be noted that with increasing grade level, the slope of a regression line would become flatter. The degree of slope is much less than would be expected by a review of the literature, primarily Underwood and Schulz's review and hypothesized relationship (1960, p. 282).

An analysis of variance was executed on the data, after Winer's (1962) procedure for unequal cell frequency using the harmonic mean. The results of the analysis are presented in Table 9.3. As would be expected from the observations concerning the slopes for the three grades, the interaction between grade level and performance is significant. Proceeding to an examination of simple effects, grades produce significant ($p < .01$) variation at each association value

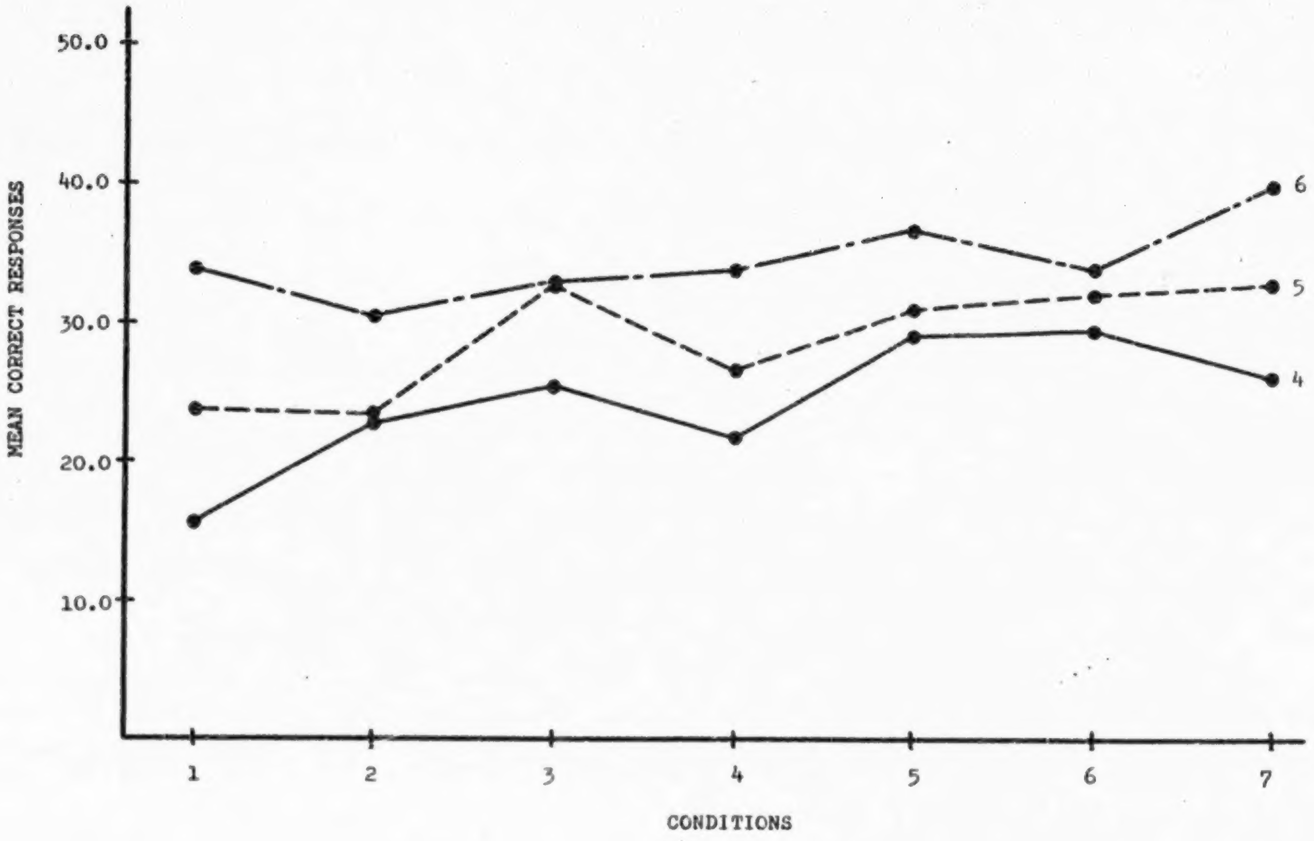


Fig. 9.1 Mean correct responses for grades; by conditions.

level except for the list in Condition 6 which has a mean association value of 70.0%. These differences are consistent with prior experimentation (Gaeth, 1960; 1963) and with results reported in this project.

An examination of simple effects for association value at each grade level indicates the expected significance ($p < .01$) of changing association value. However, the more specific goal of the experiment was to examine the effect of a specific amount of change. The Tukey (a) procedure (Winer, 1962) for *a posteriori* comparisons was applied at each grade level. The results of these computations are presented in Table 9.4. In that table, the conditions are identified by the mean association value of the response list and ranked in order of performance, from low to high, for each grade.

Table 9.2. Means and standard deviations of the number of correct responses, by conditions and grades.

		Conditions (Mean Association Value)						
Grades		1 (19.8)	2 (30.6)	3 (40.0)	4 (50.6)	5 (60.6)	6 (70.0)	7 (80.6)
4	$\bar{X}$	15.4	22.8	25.1	21.7	29.1	29.4	26.1
	SD	12.1	12.3	12.5	11.6	13.0	12.4	13.5
	N	64	64	64	64	64	64	64
5	$\bar{X}$	23.6	23.1	32.4	26.4	30.9	32.0	32.8
	SD	13.2	12.3	10.5	8.9	10.3	11.4	13.1
	N	64	64	64	64	64	64	64
6	$\bar{X}$	33.6	30.2	32.9	33.8	36.8	33.8	38.9
	SD	10.7	11.2	11.6	10.2	11.0	8.8	9.8
	N	39	39	39	39	39	39	39

For example, grade 4 performed lowest on the condition where the responses had a mean association value of 19.8 and highest on the list averaging 70.0, while the fifth and sixth grades were lowest

Table 9.3. Summary of the analysis of variance for seven conditions and three grades.

Source	df	MS	F
Grades (G)	2	9398.79	68.94**
Conditions (C)	6	1884.35	13.82**
G x C	12	362.87	2.66**
Within	1148	136.33	

** $p < .01$.

on list 30.6 and highest on 80.6. The mean correct performance in each case may be obtained by referring to Table 9.2 under the appropriate grade and list association value.

The startling aspect of this final test is the broad range of association values over which no difference in performance can be detected. In the sixth grade this range may be as broad as 60 points, 40 points in the fifth grade, and 50 points in the fourth grade. It would seem the notion that the associability of a stimulus is useful in predicting the rapidity with which a specific association will occur, must be called into question.

Table 9.4. Results of the Tukey (a) tests.

Grades	Conditions Ranked by Performance						
4	19.8[a]	50.6	30.6	40.0	80.6	60.6	70.0[b]
5	30.6	19.8	50.6	60.6	70.0	40.0	80.6
6	30.6	40.0	19.8	50.6	70.0	60.6	80.6

[a] Numbers identify mean association value of list.
[b] Lines connect nonsignificant differences at p = .01.

D. Summary and Conclusions

One thousand one hundred and sixty-nine students from the fourth, fifth, and sixth grades served as subjects in seven paired-associate learning tasks. The tasks differed in the mean association value of responses. The range of each list was 10 points; the means: 19.8, 30.6, 40.0, 50.6, 60.6, 70.0, and 80.6. Association values were established with an independent group of 763 fourth-, fifth-, and sixth-grade students. Archer's (1960) procedure was followed and the correlation between the values for adults and children was .84.

Results indicate a significant interaction between association value of a list and the grade level of the subjects. This restricts the interpretation of main effects, both of which were significant. It will be noted that a significant effect for grades is entirely consistent with results elsewhere in this project as well as in Part I (Gaeth, 1963) and as reported by Gaeth in 1960. Likewise, the resulting significance of the main effect for association value is not surprising. Studies with adults had indicated a strong relationship between performance and association value. Since a specific goal of the experiment was to determine the amount of change needed in association value for a significant change in performance, and to side-step the problem of the significant interaction, a post mortem examination was conducted for the effects of association value at each grade level. The results of these examinations form the core of the report.

The significant effect of association value was confirmed at each grade level with higher association value producing better performance. However, the range of association values over which no significant change in performance occurred was not consistent with what would be expected on the basis of heterogeneous lists used with adult subjects. As much as 60.8 association value points were required to alter performance, clearly not the expectation. At least one source of the discrepancy would be the use of heterogeneous lists in previous experimentation which, as mentioned in the Introduction, would accent the effect of association value. A second source of the discrepancy would be the grossness of the categories used previously to classify the association value. At least it may be said that for children, and presumably for adults in view of the lack of similarly controlled experimentation, the variability in performance attributable to association value is far less than has been supposed.

These findings add further support to the assumption that association values are not absolute indices of meaningfulness. This conclusion was initially indicated by results in Experiment VII from the use of truncated lists. It was suggested there that subjects may respond only to the range of items in the list at hand and not to the position of these items in the general hierarchy of verbal material. Thus, when presented with a list that has low variability of association values, there is markedly little difference in the rate of learning that list regardless of where it lies in terms of the overall range of association values. Only as the inter-item variance increases can performance be charted in terms of association value.

Experiment X

The Effects of Pronounceableness and Explicit Pronunciation on Learning

ABSTRACT. A total of 783 subjects from the fourth, fifth, and sixth grades were tested in a paired-associate paradigm with CCC or CVC trigrams as responses. Visual and auditory presentations were used. CCC and CVC materials were assumed to have equivalent association value. Comparisons across presentations, within a type of material, indicate that explicit pronunciation is not facilitating and that auditory presentation is inferior to visual, as a function of materials. These differences may be attributed to greater intelligibility problems with CCC material. Pronounceableness was found to be a major factor in performance.

A. Introduction

Starting with the explicit assumption that rate of learning is a function of meaningfulness, it may be shown then that measures such as association value and pronounceableness are parameters of this dimension to the extent that they interact with rate of learning. Association value has been accepted as an index of meaningfulness on the basis of such evidence. Results from the preceding experiment, Experiment IX, have suggested that moderation is recommended in characterizing the relationship between association value and rate of learning. The facilitative effect of pronounceableness is generally assumed to be due to the fact that it aids in producing an integrated unit, supraordinate to the individual letters which make up a group. Underwood and Schulz (1960) investigated pronounceableness in learning. However, their work did not involve explicit pronunciation to or by the subjects.

As a further elaboration of the roles of pronounceableness and association value in learning, Williams and Derks (1963) attempted to vary the two independently while testing the effects of modality of presentation. Their conclusion was that visually presented material is learned as a function of its pronounceableness while aural presentation "minimizes the importance of PR and is more clearly related to AV". (PR indicates the pronounceableness rating as collected by Underwood and Schulz; AV refers to association value.) Williams and Derks view the two factors as operating independently, their contributions to learning reflecting the relative efficiencies of presentation modes.

The present study was designed to test the implications of some of these assumptions. Five conditions were generated with two types of material and three types of presentation. Since Williams and Derks were unable to accomplish a complete separation of AV and PR, it was decided to vary pronounceableness holding association value constant. CCC and CVC trigrams were taken from Witmer's and Archer's lists, respectively. The sets were equated numerically for association value as reported by them. There is no basis for assuming equality of association values from the two studies, since the two did not use identical methods for rating association. One of the studies in Experiment VII, association values in children, attempted to correct this defect. On the basis of those findings, the equatability of such values, obtained from the same subjects, can be tentatively assumed. Results from Experiment IX indicated that the absolute association values of items bear little relationship to the rate of learning such items in restricted lists. Thus, the issue of equatability of values becomes relatively unimportant. It was expected that all comparisons between CCC and CVC material would show the latter to be superior on the basis of pronounceableness.

The mode of presentation was either visual, two spellings, or a spelling followed by a pronunciation. (The last two were auditory conditions.) For CCC material, only the visual or spelling presentations were used, since these trigrams do not lend themselves readily to pronunciation. The pronounceable CVC trigrams were presented aurally in the two different ways. For one condition, the trigram was spelled twice at each presentation. This condition might be viewed as analogous to the visual condition where the subjects could scan the simultaneously presented elements of the trigram more than once. For the other auditory presentation, the CVC was spelled once and pronounced once during each presentation. This might be considered parallel to the other approach which a subject might adopt in viewing the trigram; i.e., examine the elements making up the trigrams and then try to integrate them into a unit by means of pronunciation.

If the conclusions of Williams and Derks are correct, then all of the auditory conditions should be poorer than their corresponding visual conditions, since association value is held constant. This should be true of both kinds of trigrams. It would also be predicted that the auditory conditions will not differ among themselves (again, since AV is constant), while the visual conditions will differ significantly with changes in pronounceableness.

B. Experimental Procedures

1. Subjects. A total of 783 children in grades 4, 5, and 6 in the Detroit Public Schools participated in the experimental conditions.

2. Materials. Two sets of six stimulus-response pairs were selected for the experiment. Single letters were used as stimuli, trigrams formed the responses. Letter duplication was held to a minimum within the materials available (CCC and CVC trigrams of low association value). Items were selected such that the two lists might be considered equal in association value.

Table 10.1 presents the per cent of subjects who indicated that the trigram in question reminded them of a word as obtained from children (Experimental) and from adults (Witmer and Archer). Children's values are obtained from Table 7.3 (Form H) of Experiment VII. Lists differing in association value by as much as 40-60% were shown, in Experiment IX, to produce no differences in performance. On this basis, and to the extent that CCC and CVC association values can be compared (see Experiment VII-3), it is contended here that the lists can be treated as being equal in AV.

3. Procedure. Using the paired-associate paradigm, the items were presented with a slide projector activated by a tape recorder. The Ampex-Bell & Howell system was used. Allowing for projector activation and de-activation, a stimulus item was presented for approximately 2.5 sec followed by a response of like duration during

Table 10.1. Stimulus-response pairings and association values for the two types of material.

CCC				CVC			
Stim.	Resp.	Exper. %age	Witmer %age	Stim.	Resp.	Exper. %age	Archer %age
F	PZK	10	25	P	KEB	31	25
H	RGW	21	25	H	ZOT	40	28
L	SJQ	10	25	L	VAF	22	22
M	DWB	13	17	M	GEC	26	17
V	TCJ	10	21	Q	YUD	38	27
X	NQS	10	21	X	SIJ	18	14
	$\bar{X}$	12.3	22.3		$\bar{X}$	29.2	22.2

learning trials, with a 5.5 sec inter-pair interval. On a test trial the response was eliminated and the inter-pair interval given to recording of the response by the subject. A 10 sec inter-trial interval was used. All three letters of a response in the appropriate order were required for correctness. Ten learning and 10 test trials were alternated.

Duration of stimulation was equated for the two modes of presentation. The time involved in two spellings or a spelling-pronunciation of a trigram was controlled so that the duration was approximately 2.5 sec. It is acknowledged that two spellings, necessarily serial in presentation, may not be equivalent to the simultaneous presentation of three letters by a slide projector. However, the question of equality of stimulation across modalities when dealing with verbal material has not yet been settled in the literature.

C. Results and Discussion

Table 10.2 presents the mean correct responses, standard deviations, and sample sizes for all conditions administered. Not all conditions were administered to fourth-grade sections. The scores indicated that testing below the fifth grade produced levels of performance which could not be interpreted as learning. Fourth-grade performance with visually presented CCC trigrams and auditorily presented CVC trigrams is very low. Chance performance would be on the order of 10 correct for 10 trials. In spite of performance

Table 10.2. Means and standard deviations of the number of correct responses, by conditions and grades.

Conditions		Grades		
		4	5	6
CCC-A	$\bar{X}$		5.18	7.61
	SD		5.55	7.32
	N		56	72
CCC-V	$\bar{X}$	9.87	13.40	13.58
	SD	7.62	6.98	8.47
	N	107	35	64
CVC-A$_{sp.}$	$\bar{X}$		13.00	21.49
	SD		11.87	15.76
	N		59	65
CVC-A$_{pro.}$	$\bar{X}$	8.00	17.36	16.06
	SD	6.99	12.00	13.14
	N	31	33	71
CVC-V	$\bar{X}$	15.78	15.87	21.26
	SD	11.71	10.98	13.08
	N	98	31	61

comparable to fifth-grade levels, with visually presented CVC trigrams, the fourth-grade testing was discontinued. It was felt that the fourth-grade performance over all conditions would not be a valid estimate of the effects of pronounceableness. Figure 10.1 (p. 150) graphically presents the fifth- and sixth-grade performance given in Table 10.2.

A three-way analysis of variance, grades by pronounceableness by modality, was conducted on the data for grades 5 and 6, excluding the CVC-$A_{pro.}$ condition which had no counterpart in the CCC material. It must be noted that the interpretation of the results of this analysis are to be qualified by the very low performance of both fifth and sixth grades with auditory presentations of CCC material. As in the fourth grade, performance in this condition cannot be interpreted as learning.

Table 10.3 presents the summary of the analysis. All main

Table 10.3. Summary of the analysis of variance for grades, pronounceableness, and modality.

Source	df	MS	F
Grades (G)	1	1975.82	17.60**
Pronounceableness (P)	1	6326.35	56.35**
Modality (M)	1	2191.13	19.52**
G x P	1	1059.46	9.44**
G x M	1	252.10	2.24
P x M	1	752.68	6.70**
G x P x M	1	33.89	.30
Error	442	112.27	

** $p < .01$.

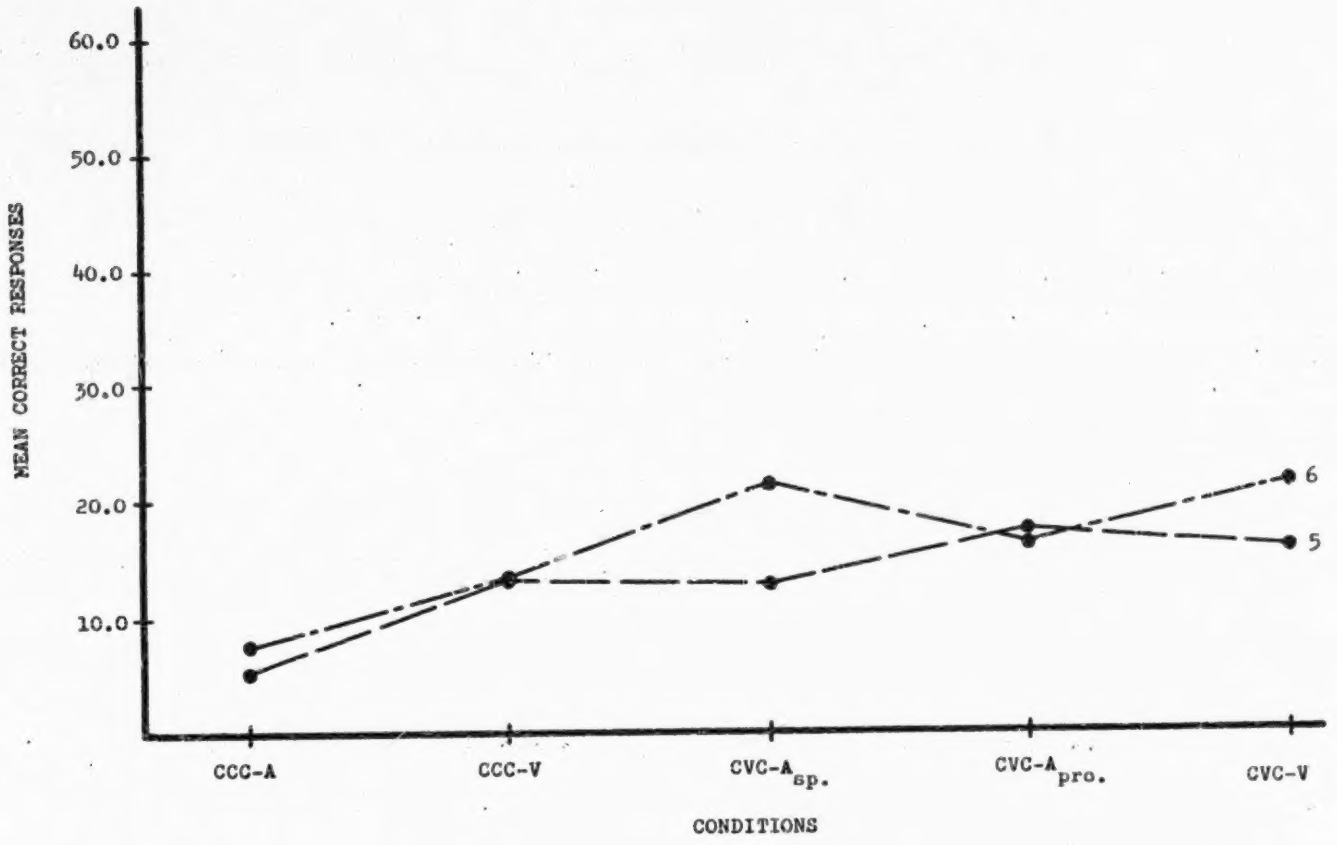


Fig. 10.1 Mean correct responses for grades; by conditions.

effects were significant. A visual presentation was superior to an auditory; CVC trigrams to CCC trigrams; and sixth grade superior to fifth grade although this aspect is restricted to CVC material. The limited area of sixth-grade superiority was confirmed by the significant interaction between grade 5 and pronounceableness. Lastly, a significant interaction between pronounceableness and modality was found. It is suggested that this interaction cannot be interpreted inasmuch as CCC-A cannot be considered a valid estimate of performance. Scores could be attributed to chance alone.

Performance on the three CVC conditions was compared for each grade to evaluate the effect of explicit pronunciation upon performance. The results of these analyses, presented in Table 10.4, show significance only at the 5% level for grade 6, where CVC-A$_{pro.}$ is

Table 10.4. Summaries of the simple analyses of variance for three CVC conditions, grades 5 and 6.

Grades	Source	df	MS	F
5	Conditions	2	221.3	1.24
	Within	120	178.3	
6	Conditions	2	644.6	3.27*
	Within	194	197.2	

* $p < .05$.

inferior to the other two modes of presentation. This is in direct contrast to our expectations.

D. Summary and Conclusions

With regard to the hypotheses advanced in the introduction, auditory conditions are found to be inferior to visual although this is largely due to the low performance on auditory CCC material. Comparing the CVC conditions, nonsignificant reversals are found in both grades in the ordering of visual and auditory presentations. Contrary to the prediction, auditory conditions do differ among themselves. The source of this difference cannot be solely attributed to the parameters of this experiment. It is suggested that one factor which may have had a large part in the low auditory CCC performance was a reduction of intelligibility of the elements of the trigrams in that more intelligible material (vowels) constituted one-third of the material in a CVC-A condition. No facilitation was provided by explicit pronunciation of CVC trigrams, suggesting that integration occurs spontaneously with appropriate materials.

Taken as a whole, this experiment provides evidence that a significant relationship holds between performance and pronounceableness. Other findings are confounded with a probable lack of validity in auditory CCC performances.

Experiment XI

The Effect of Similarity Upon Learning

ABSTRACT. It was hypothesized that formal intralist similarity would interfere more with paired-associate learning in children than would conceptual similarity. Experiment 1 tested 51 subjects each with five conditions in grades 4-6. Formal similarity interfered more with the learning of items low in meaning while conceptual similarity seemed to interfere more with highly meaningful material. Relatively poorer performance by grade 5 suggested a transition in the strategy used to learn. Experiment 2 increased the dimensions of similarity with the expectation that grade 4 would be most affected. Results show that grade 4 performance was facilitated but grade 5 was again relatively poorer.

A. Introduction

Intralist similarity is recognized as a major variable affecting paired-associate learning. Three kinds of similarity have been described: "formal" as measured by letter duplication, "meaningful" as determined by the tendency of words to elicit one another, and "conceptual" in which the words are instances of a supraordinate class (Keppel, 1964; Underwood, Ekstrand, and Keppel, 1965). These categories are not mutually exclusive; items selected for a learning task can be termed similar according to one or more of these definitions. Also, meaningful similarity can be subsumed under conceptual similarity. However, these terms have usefulness in describing the dimensions along which the items vary.

All three kinds of similarity produce interferences. Formal similarity is most effective when the material to be learned is low in meaningfulness. With highly meaningful material, formal similarity no longer plays a role but is replaced by conceptual and/or meaningful similarity. From such evidence, it may be assumed that verbal material is responded to initially on the basis of its meaning and, only secondly, on other dimensions such as spelling. Lists of words with similar spellings but different referents should not be learned at a different rate than lists of words which differ both in spelling and referent. However, if the verbal material is not words, performance should be adversely affected by letter duplication.

There is evidence to suggest that, at least with college students, strategies are employed in paired-associate learning. In essence, the function of the strategy is to reduce the complex elements of the tasks to single units. For example, pronunciation aids in integrating sets of letters. Meaning can also reduce sets of letters to single elements. Mediators are employed frequently to integrate the stimulus and response into a unit. Newman (1963) directly examined strategies and concluded that subjects attend to the entire stimulus at the beginning of training but later respond to selected aspects of the complex stimulus, again tending to reduce it to a single element.

Re-examining the situation in which low meaningful verbal stimuli are being learned, it would seem that a curvilinear relationship should be obtained between amount of interference with learning and amount of formal similarity. No letter duplication would produce zero interference; a monotonic relationship would be found between the variables as the amount of letter duplication increases up to some maximum; beyond some point, further duplication should serve to reduce the amount of interference by allowing the subject to identify early in the learning experience those stimulus elements which are duplicated, and therefore, irrelevant. In effect, then, excessive letter duplication would increase the rate at which the subject is able to reduce the stimulus to a single element, thereby facilitating learning. The extreme situation in which all the letters but one are duplicated in every item should produce relatively little interference since the critical letter, a single unit, would be rapidly isolated from its constant surroundings.

These predictions would in all probability be borne out if college students are used as subjects. Keppel (1964) points out that no studies of the effects of similarity have been done with children. He suggests that younger subjects may respond differently, with formal similarity exerting a greater effect upon performance. This hypothesis is tenable for two reasons: (a) Children, being more concrete than adults (Piaget, 1957), may respond to the appearance of the stimulus more than to is meaning, and (b) the ability to attend selectively to portions of a complex stimulus may vary as a function of age or experience with the result that younger children might be "compelled" to attend to all of the stimulus elements presented. In the case of words, this would simply mean that children would be unable to attend to meaning without being aware, at the same time, of spelling and pronunciation. In either case, it would be predicted that children would perform at a lower level on a paired-associate task where the stimuli are words with similar spellings than on a task where the stimuli are unique in both spelling and meaning.

A corollary to the assumption that children are more influenced by formal than other kinds of similarity would be that they are also more limited in the strategies available for learning. This hypothesis was tested by determining the ability of children to attend to parts of a stimulus. The unique element was embedded in a constant matrix. Newman's data suggest that college students would rapidly identify the critical elements and performance would approximate that of a control condition where the stimuli were presented without the matrix. If children approach the task concretely, they would fail to discriminate the critical stimulus and performance would be significantly poorer than in the control condition.

The present study was designed to test these hypotheses as well as to evaluate generally the effects of two kinds of intralist similarity upon the paired-associate performance of children. Formal and conceptual similarity were selected for investigation.

B. Experiment 1

1. Subjects. A total of 918 subjects from grades 4, 5, and 6 of the Detroit Public Schools was tested in the five conditions. Entire classrooms were used with more than one classroom per grade tested. The different classes from the same grade were taken from different schools. In order to facilitate computation, all sample sizes were reduced randomly to 51, the frequency of the smallest cell. Thus, results from a net total of 765 subjects were used in

this experiment. Two control conditions using data collected from a previous study (Gaeth, 1963) were similarly reduced to 51 subjects each.

2. Materials. The specific stimuli for the five experimental conditions are presented in Table 11.1 along with the appropriate responses. The S-R pairs for the two control conditions (V_2 and V_3) are also given. Condition A consisted of single-letter consonants for both stimuli and responses. The same responses were used for the remaining conditions and, where the stimuli contained the consonants from the first condition, the same S-R pairings were maintained. Condition B used the critical consonants from A but added the letters "AN" creating three-letter words of the form "_AN". Condition C used the "_AN" stimuli but rearranged the order of the letters in the stimuli to the form "A_N" so that the critical consonant was surrounded by a constant matrix. Condition D used three different

Table 11.1. Stimulus-response pairings for five experimental conditions (A-E) and two control conditions (V_2 and V_3).

Stimulus Items							Response Items	
A	B	C	D	E	V_2	V_3	A-E	V_2-V_3
F	FAN	AFN	AFN	HAIL	WUB	CAT	X	H
T	TAN	ATN	ATN	SNOW	KEZ	ICE	J	M
P	PAN	APN	PNA	ICE	JID	ARM	G	V
C	CAN	ACN	CNA	SLEET	DAQ	RUG	K	L
V	VAN	AVN	NVA	RAIN	WOJ	SKY	Z	X
M	MAN	AMN	NMA	FOG	ZEG	GUN	L	F

arrangements of the "_AN" stimuli in order to vary the position occupied by the critical consonant. The last condition designed for this study, E, used stimuli which were conceptually similar, all being instances of "weather" or kinds of precipitation.

Condition A was designed to evaluate the use of strategies in Condition B, C, and D, all of which maintained a high degree of formal similarity with apparent meaningfulness varied. (The term "apparent meaningfulness" is used to indicate that no direct evaluation of the meaningfulness of these items was attempted. However, they are not directly recognizable as words, being anagrams, and Condition D is assumed to be lower in "apparent meaningfulness" since the form of the anagram is varied among the stimuli.) Condition A functioned, therefore, as a control for formal similarity.

The other two control conditions consisted of three-letter nouns (Condition V_3) or trigrams with low Glaze's values (Condition V_2) as stimuli with consonants for responses. Different response letters reflect the fact that these conditions were taken from a previous study as noted above. There is no reason to suspect that differences would result from the change in response letters. The stimuli in these two conditions were considered to be of low intralist similarity both formally and conceptually.

3. Procedure. The recall form of a paired-associate learning paradigm was used. All stimuli and responses were presented by an automatically controlled slide projector. Ten learning trials, where both S and R were presented, alternated with 10 test trials, where only S was shown, for a total of 20 trials. Six random orders

were used; the learning trial orders were different from test trial orders. During the learning trials, S was on for 2.5 sec followed immediately by R for 2.5 sec, with an inter-pair interval of 5.5 sec, and an inter-trial interval of 10 sec. During the test trials, S appeared for 2.5 sec with an inter-item interval of 5.5 sec to allow the subject to write down the response in booklets provided.

4. *Results and Discussion*. The results obtained for the five experimental conditions from grades 4, 5, and 6 are summarized in Table 11.2 along with the data from the two control conditions.

Table 11.2. Means and standard deviations of the number of correct responses for five experimental and two control conditions, by grades.

Conditions		Grades		
		4	5	6
A	$\bar{X}$	43.53	30.80	45.29
	SD	15.14	18.45	13.55
B	$\bar{X}$	31.63	38.59	39.12
	SD	13.46	13.66	15.01
C	$\bar{X}$	16.29	19.29	28.88
	SD	12.89	13.15	14.74
D	$\bar{X}$	15.43	12.49	16.51
	SD	10.21	8.28	10.72
E	$\bar{X}$	26.12	33.98	40.86
	SD	12.47	13.09	13.21
V_2	$\bar{X}$	23.23	25.92	29.82
	SD	12.20	12.85	12.62
V_3	$\bar{X}$	35.55	37.92	44.82
	SD	12.90	14.40	8.68

If Conditions B, C, and D are compared, information is obtained concerning the effect of changes in apparent meaningfulness holding formal intralist similarity constant. The summary of the analysis of variance of these three conditions across the three grades is presented in Table 11.3. As indicated there, conditions and grades as well as the interaction were significant sources of variance.

The Scheffe procedure (Winer, 1962) was used to examine the differences between selected means. This is a very conservative test, especially when cell frequencies are equal. To be even more cautious in interpretation, the 1% level of significance was used for such comparisons. All differences described as significant are at that level unless otherwise stated.

Table 11.3. Summary of the analysis of variance for Conditions B, C, and D and three grades.

Source	df	MS	F
Conditions (C)	2	18775.08	117.62**
Grades (G)	2	1974.12	12.37**
C x G	4	671.31	4.20**
Within	450	159.63	

** $p < .01$.

Because of the significant interaction between grades and conditions, an analysis of the simple effects was necessary. The Scheffe procedure showed that the significant interaction can be attributed to the performance of grade 6 on Condition C. This is illustrated in Figure 11.1. The three grades did not differ significantly on

Conditions B and D, but grade 6 was significantly better than grade 4 on Condition C. The three conditions showed the same rank order of performance in the three grades; however, Condition B was significantly better than both C and D in grades 4 and 5. In grade 6, performance on B and C were not different statistically while both were significantly better than D.

The comparison of these conditions suggests that letter duplication has less effect when the stimuli are meaningful words than when the stimuli are apparently nonmeaningful sets of letters. This is consistent with findings concerning adult performance on tasks where the stimuli exhibit high formal similarity and are either words or low meaningful trigrams (Underwood, personal communication). The performance of the three grades on Condition C suggests that the ability to detect the critical element or to ignore the non-critical interfering elements increases with age or experience when the stimuli are of a constant form which facilitates such recognition. However, performance is uniformly poor in Condition D where the position of the critical element varied.

Further information is obtained concerning the ability to attend to only the critical aspects of the stimulus if Conditions A, C, and D are compared. Analysis of variance of these three conditions across the three grades showed that conditions, grades, and the interaction are significant as indicated in Table 11.4. The major source of the interaction is the reversal of grades 4 and 5 on Condition A, illustrated in Figure 11.2. The Scheffe analysis of simple effects showed that grades 4 and 6 performed similarly on Condition A

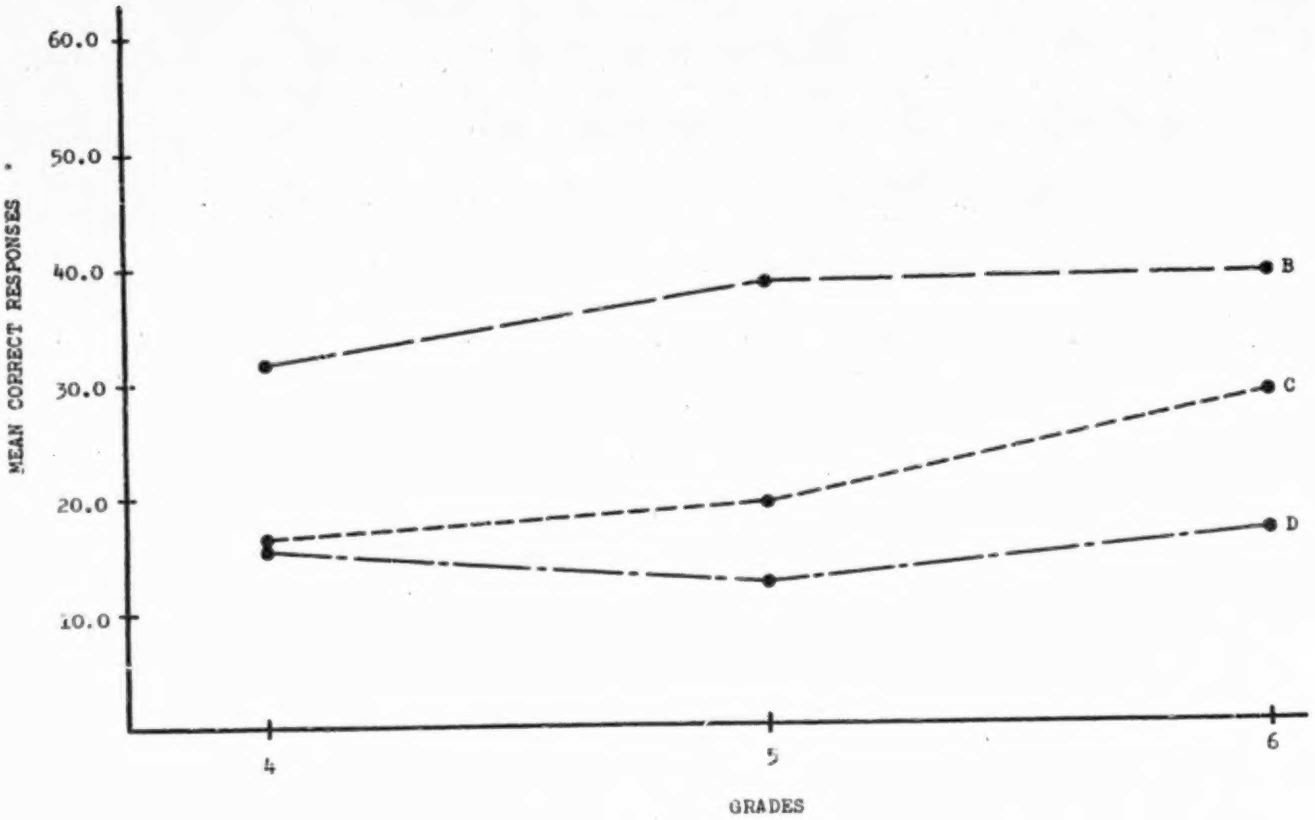


Fig. 11.1 Mean correct responses for Conditions B, C, and D; by grades.

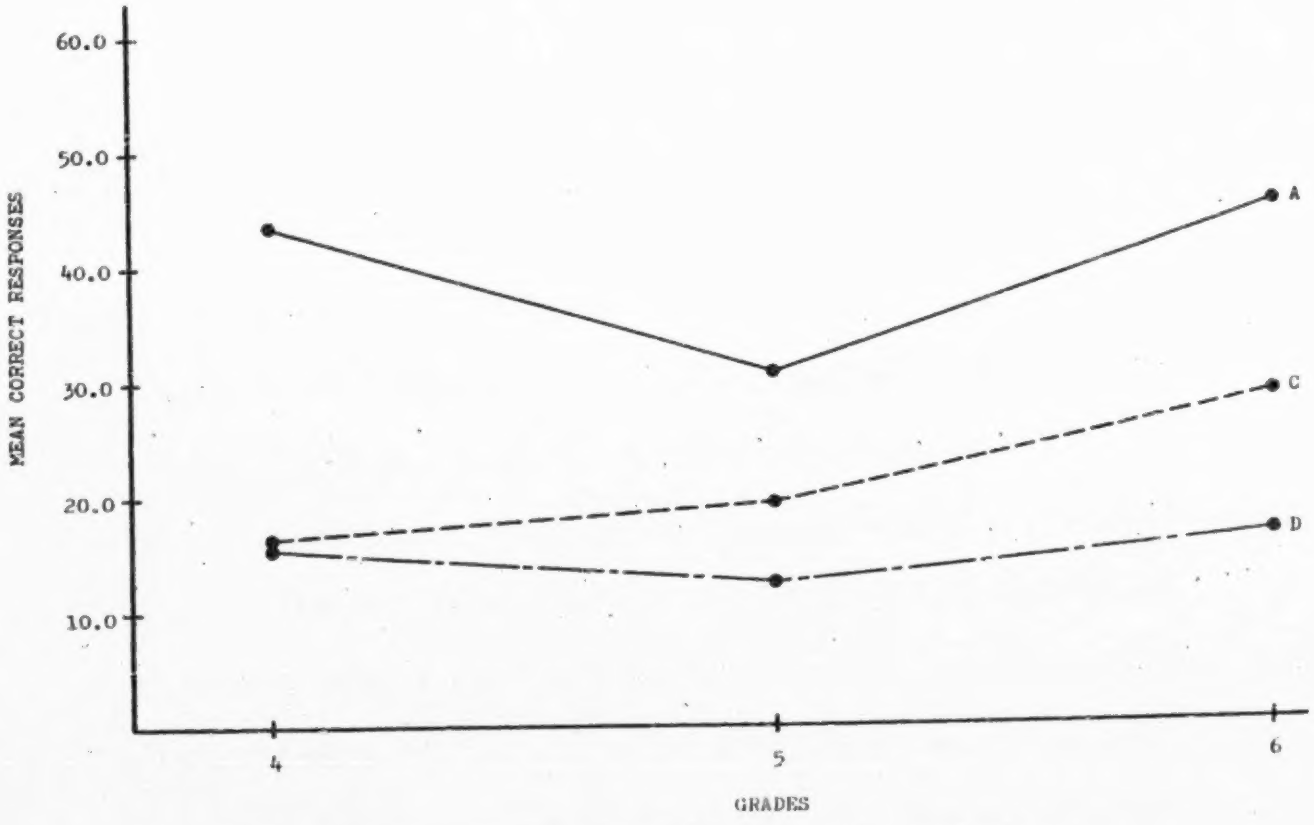


Fig. 11.2 Mean correct responses for Conditions A, C, and D; by grades.

Table 11.4. Summary of the analysis of variance for Conditions A, C, and D and three grades.

Source	df	MS	F
Conditions (C)	2	25778.52	145.29**
Grades (G)	2	3366.20	18.97**
C x G	4	1123.54	6.33**
Within	450	177.43	

** $p < .01$.

both being significantly better than grade 5. On Condition C only grades 4 and 6 were significantly different while no differences were found among the three grades on Condition D. When the performance on conditions within each grade is examined, the same rank order is found with A being highest, and D lowest. The differences between C and D in grade 4 were not significant but both were significantly poorer than Condition A. For the fifth grade, only the difference between A and D was significant, while each condition was statistically different from the other in grade 6.

These findings suggest that subjects of this age level and experience are essentially unable to identify critical stimulus cues which are surrounded by the same letters. Post-experimental inquiry supports the conclusion that all elements of the stimulus were attended to. Subjects never reported isolating only the relevant cues, although they recognized that two of the letters were the same in all the stimuli. No reports were obtained to suggest that the stimulus elements were rearranged to form meaningful units although all were anagrams of familiar words.

A comparison between Condition A and the control Condition V_3 provides evidence concerning the effectiveness of words versus single letters as stimuli. It might be expected that lack of differentiation between the classes of stimulus and response items in Condition A would produce interference in the form of response errors due to stimulus intrusions. The summary of the analysis of variance, given in Table 11.5, shows no significant difference due to conditions; however, a significant grade effect and a grade by condition interaction were obtained. Examining individual comparisons by the Scheffe method, grade 5 was identified as the source of both significant effects, being significantly lower on Condition A than either grades 4 or 6 which do not differ. These are shown in Figure 11.3. No other significant differences are obtained in all possible comparisons.

Table 11.5. Summary of the analysis of variance for Conditions A and V_3 and three grades.

Source	df	MS	F
Conditions (C)	1	15.11	.08
Grades (G)	2	2918.36	14.67**
C x G	2	1453.20	7.30**
Within	300	198.98	

** $p < .01$.

Conditions C, D, and V_2 vary formal similarity while keeping the meaningfulness of the stimulus items low. The summary of this analysis of variance, presented in Table 11.6, shows that grades and conditions are significant sources of variance ($p < .01$) while the interaction of the two is significant only at the 5% level. Since a conservative approach has already been adopted, the latter is considered not significant. A Scheffe analysis of the main effects showed that the three conditions are significantly different from one another with V_2 being the best and Condition D the poorest. As for the grades, no difference is found between grades 4 and 5 but both are significantly poorer than grade 6. These results, presented graphically in Figure 11.4, suggest that, with low meaningful stimuli, intralist similarity produces a significant decrement in performance. This decrement is even greater as the distinguishing elements of the stimuli become more obscure.

Table 11.6. Summary of the analysis of variance for Conditions C, D, and V_2 and three grades.

Source	df	MS	F
Conditions (C)	2	5116.26	34.97**
Grades (G)	2	2052.44	14.03**
C x G	4	466.44	3.19*
Within	450	146.31	

** $p < .01$.
* $p < .05$.

The effect of different kinds of intralist similarity with highly meaningful material can be assessed by analyzing the data for Conditions B, E, and V_3. Condition B represents high formal similarity

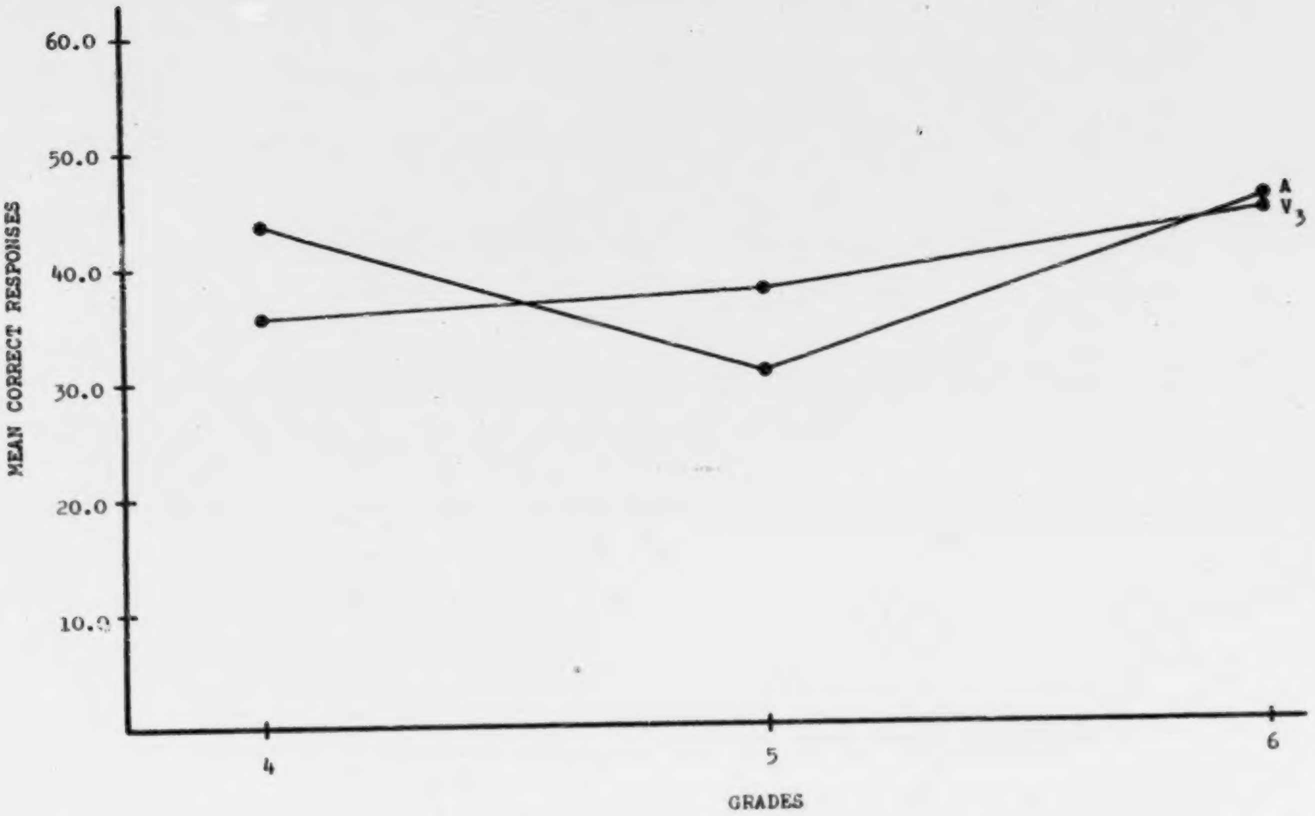


Fig. 11.3 Mean correct responses for Conditions A and V_3; by grades.

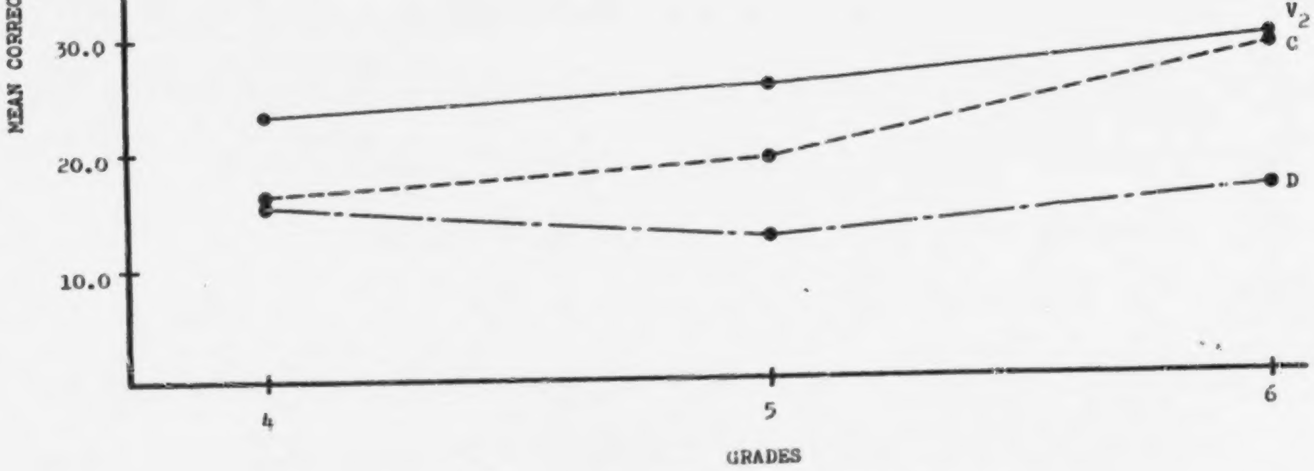


Fig. 11.4 Mean correct responses for Conditions C, D, and V_2; by grades.

while E introduces conceptual similarity among the stimuli. Table 11.7 presents the summary of the analysis of variance and shows that only the two main effects were significant. Figure 11.5 (p. 170) portrays the relationships among the conditions and grades.

Table 11.7. Summary of the analysis of variance for Conditions B, E, and V_3 and three grades.

Source	df	MS	F
Conditions (C)	2	1277.38	7.49**
Grades (G)	2	4231.46	24.81**
C x G	4	309.86	1.82
Within	450	170.58	

** $p < .01$.

The Scheffe procedure was used to evaluate comparisons of conditions and grades and showed that V_3 was superior to E while B did not differ from either. The differences among the three grades were all statistically significant with grade 6 performing best and grade 4 the poorest. The results suggest that both formal and conceptual similarity interfere with performance, the latter producing perhaps a greater effect. However, the lists in Conditions B and E differed according to word frequency measures with the conceptual list being lower in this regard. Performance on Condition E may reflect this factor as well as the similarity dimension.

Evidence has been presented which suggests that the ability to attend to specific aspects of a stimulus increases with age or experience. The significantly poorer performance of the fifth grade on Condition A as compared with grades 4 and 6 may reflect a transition in the learning process at this level. Grade 4 subjects may have little difficulty with the task because much of their experience involves isolated letters and rote learning. By the sixth grade, it may be assumed that subjects are now responding to meaningful words, having well-developed reading skills. They should also have mastered several ways of learning and demonstrate greater flexibility in a learning situation. With this combination of skills, they may learn the S-R pairs of Condition A by making words of them. The fifth grade then may be viewed as being in the process of changing from a rote approach to the entire stimulus as demonstrated by fourth-graders to a selective approach emphasizing verbal skills as suggested by the performance of sixth-graders.

C. Experiment 2

1. Introduction. The first experiment suggested that the ability to ignore aspects of the stimulus increases with age. Fourth-grade subjects performed poorer than those in grades 5 and 6 in those conditions where selective attention to portions of the stimulus would facilitate stimulus differentiation. These findings are consistent with the fact that younger children are usually described as being stimulus-bound (Cunningham, 1965).

It was hypothesized that fourth-grade children attend to all aspects of the stimulus situation, being unable to ignore those parts which are either irrelevant or interfering. Therefore, as the proportion of similar stimulus elements increases, performance of these subjects should be debilitated to a greater extent than performance of older children. In order to test this hypothesis, Condition B from Experiment 1 was replicated with the addition of an auditory dimension. The stimuli in this condition are similar in spelling and in pronunciation while being highly dissimilar in meaning. It was predicted that the addition of pronunciation would increase similarity among the stimuli resulting in significantly poorer performance by fourth-grade subjects with a decreasing effect on fifth- and sixth-grade performance when compared to the control condition.

2. Subjects. One hundred and forty-four additional subjects from grades 4, 5, and 6 were tested with the modified material. Only one classroom was available for the sixth grade; two classes each were pooled for grades 4 and 5 and randomly reduced to 51.

3. Procedure. The same procedure as described in Experiment 1 was followed. The only change was the addition of the auditory dimension by use of a tape recorder. The stimuli were always presented bimodally, the responses (during the learning trials) were presented only visually. The onset of the auditory and visual presentation of the stimuli was synchronized.

4. Results and Discussion. The data obtained from this experiment (Condition B') are presented along with the data from Condition B of Experiment 1 (the control condition) in Table 11.8 and Figure 11.6. Analysis of variance of the results confirmed what is apparent by examining the means. As shown in Table 11.9, a significant difference due to grades was obtained and the interaction of

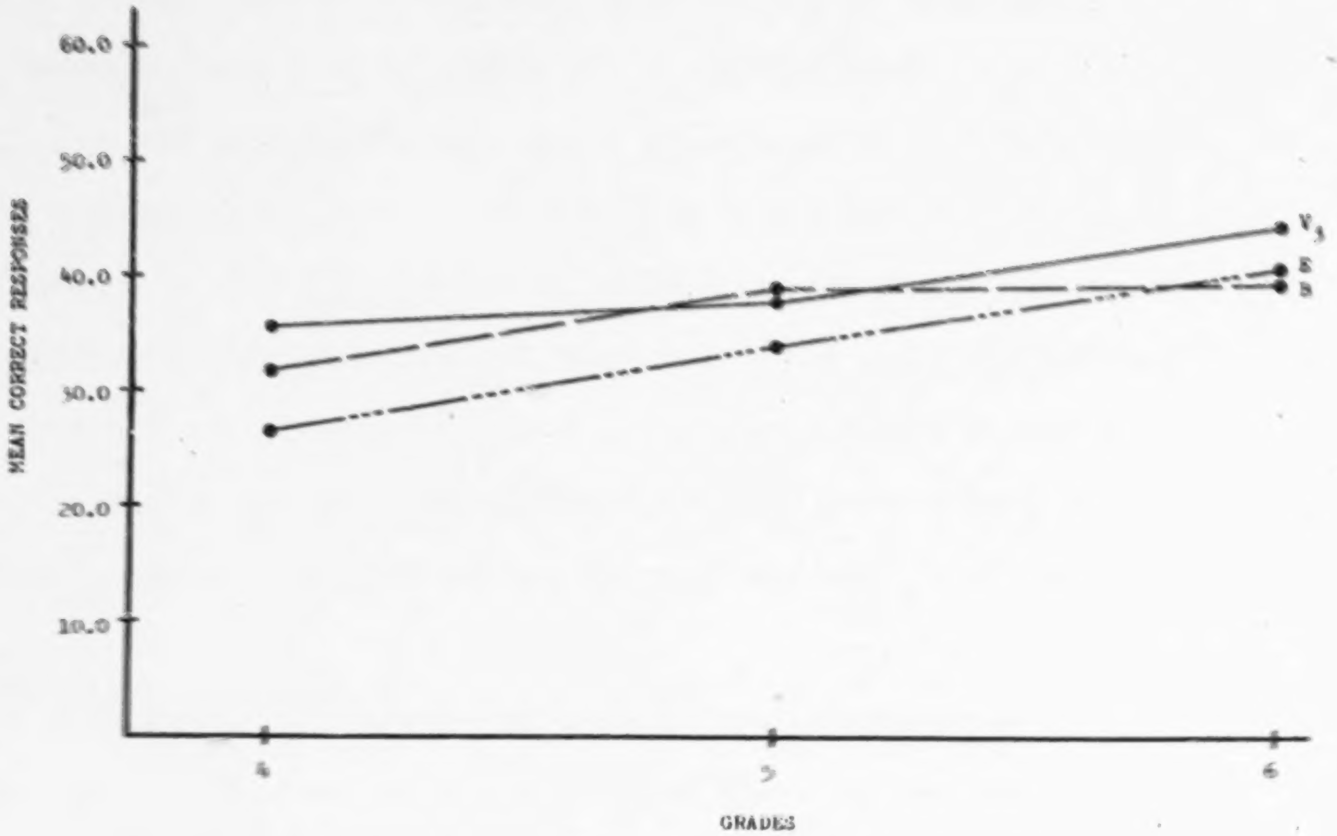


Fig. 11.5 Mean correct responses for Conditions B, E, and V_3; by grades.

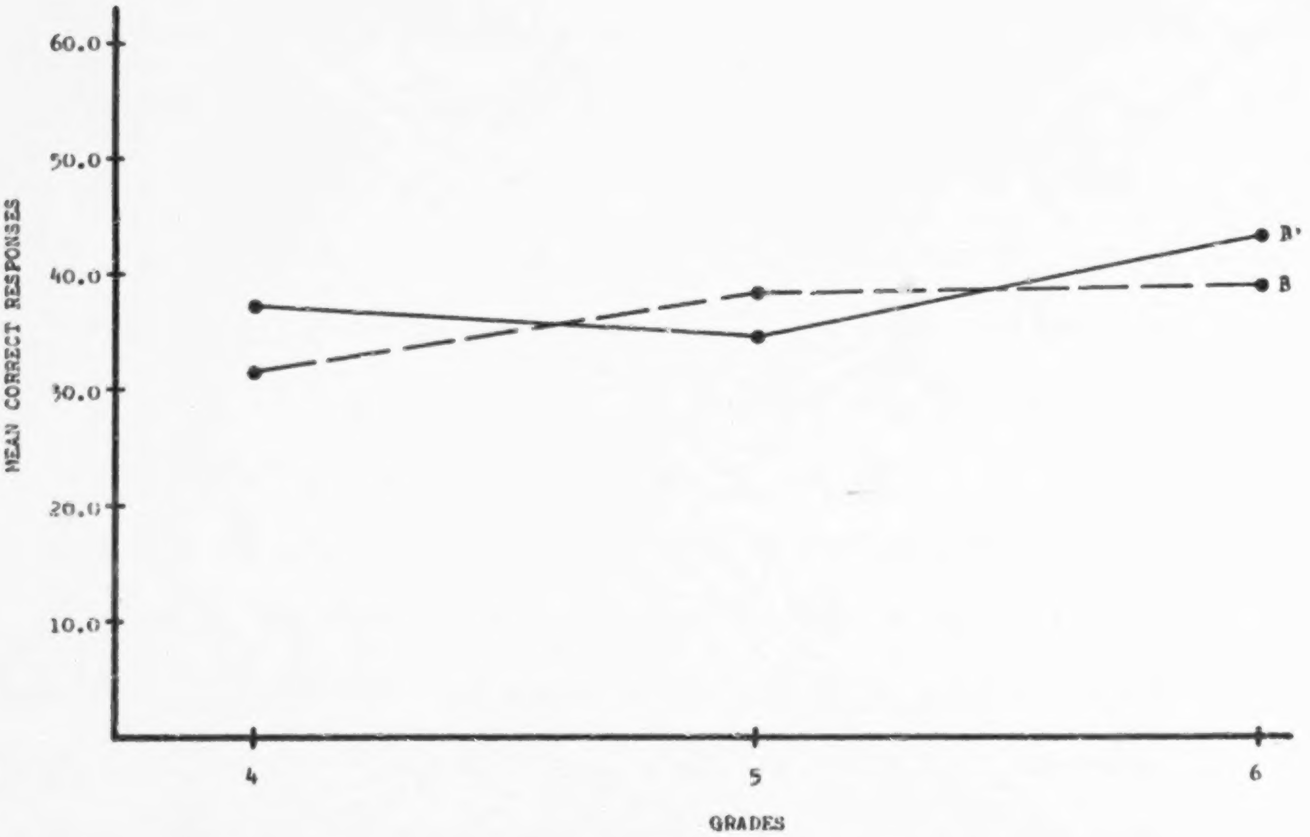


Fig. 11.6 Mean correct responses for Conditions B' and B; by grades.

Table 11.8. Means and standard deviations of the number of correct responses for Condition B' and B by three grades.

Conditions		Grades		
		4	5	6
B'	$\bar{X}$	37.45	34.80	43.38
	SD	12.68	12.56	11.03
	N	51	51	42
B	$\bar{X}$	31.63	38.59	39.12
	SD	13.46	13.66	15.01
	N	51	51	51

grades and conditions was also significant, but at a lower level ($p < .05$). Conditions themselves, however, did not differ. The source of the interaction is the relatively low performance of grade 5 on Condition B' as compared to the other grades on this condition or as compared to the performance of this grade on the control condition.

Table 11.9. Summary of the analysis of variance for Conditions B' and B and three grades.

Source	df	MS	F
Grades (G)	2	1156.13	6.65**
Conditions (C)	1	324.62	1.87
G x C	2	655.40	3.77*
Within	291	173.78	

** $p < .01$.
* $p < .05$.

The results of Experiment 2 lead to the rejection of the hypothesis that fourth-grade subjects are unable to selectively attend to stimuli. The addition of pronunciation, in fact, significantly improved performance in grade 4 ($\underline{t} = 2.25$; df = 100; $p < .05$) implying, perhaps, that implicit pronunciation did not accompany the stimuli in Condition B. Interestingly, the transitional role of the learning process in the fifth grade was again demonstrated; this grade apparently was more disturbed by the increased similarity of Condition B' than was the lower grade.

D. Summary and Conclusions

This study was designed with the broad purpose of investigating the effects of formal and conceptual similarity among stimuli upon paired-associate learning with grade-school children as subjects. The results show that children respond to similarity in much the same manner as do adults. Contrary to Keppel's expectations, and to the hypotheses tested here, formal intralist similarity does not seem to be the paramount factor in determining the performance of children. As the meaningfulness of the stimuli increased, holding formal similarity constant, the performance of the children improved. With stimuli classified as low in meaningfulness, formal similarity interfered with performance. Both these findings are consistent with adult performance. In addition, there is some evidence suggesting the conceptual similarity among stimuli may produce more interference than does formal similarity. However, the two lists of stimuli differed with respect to familiarity, a factor which also affects performance. At present, it is more conservative to attribute the difference in performance to the word-frequency factor until further information is available. If the finding is not an artifact, this is further evidence for the conclusion that children and adults respond alike to the dimensions of intralist similarity.

One aspect which distinguishes the performance of children and adults is the inferred use of strategies in learning the task. Children not only are less practiced in this behavior, but they seem to have fewer strategies available. There is every indication that the major approach used by fourth-grade subjects is one involving rote learning. The sixth grade may be employing adult strategies; e.g., using verbal skills and exhibiting less rigidity in its approach to tasks. These changes in strategies are inferred mainly because of the poor performance of the fifth grade as compared to either of the other two grades. Since a continuum of performance across grades was not obtained, it was conjectured that the fifth grade may represent a change in the mode of attack used by children. They may be in the process of discarding old learning techniques and replacing them with new ones, but are not practiced in the application of these as yet. Consequently, a drop in performance is shown by this grade when compared with the grades above and below it. This view of the child's abilities is consistent with Piaget's (1957) analysis of the development of intelligence.

Experiment XII

Learning as a Function of Audio-Frequency Differences and of Cognitive Restructuring of the Task

ABSTRACT. Fourth- and sixth-grade subjects were initially tested with two paired-associate tasks which differed only in the frequency intervals among stimulus items. Stimuli were 1/3 octave bands of noise. It was concluded that no differences in performance could be detected as a function of these intralist variations. In addition, fourth-grade subjects were tested under conditions which restructured the learning task by emphasizing frequency differences as such, using the same stimuli. Significant increases in performance were found with modifications of the task, a finding which has implications for the methods and criteria used for auditory training of hearing-handicapped children.

A. Introduction

In Part I (Gaeth, 1963) a number of cross-modality comparisons were made; i.e., auditory versus visual presentation of classes of material. The three classes of materials were nouns, consonant-vowel-consonant trigrams, and nonverbal materials. Modified electrical symbols were used as nonverbal visual materials; sounds different in frequency and modulation were auditory materials. A problem arose in the interpretation of the nonverbal comparisons which was not faced in the two classes of verbal materials. That is, no independent assessment of inherent list difficulty could be made in that there were no common parameters by which the two types of nonverbal material could be compared.

This experiment was designed initially to explore a hypothesized relationship between physical parameters and ease of learning. One-third octave bands of noise were used as stimuli in paired-associate tasks. Two experimental conditions were generated on the assumption that changes in inter-stimulus frequency distances between learning tasks might be reflected in differences in performance in the same manner that the formal intralist similarity of verbal stimuli correlates with learning (Experiment XI).

As the initial examination of the results progressed, it became evident that two things were occurring. The general level of performance was far below that to be expected with nonverbal auditory stimuli. Secondly, neither the hypothesized relationship nor any relationship between inter-stimulus distances and learning was appearing. These facts led to the generation of two additional experimental conditions which represented modifications of the first two. The test trials were not altered. Only the learning trials and the responses were altered to provide the subject with an opportunity to make direct comparisons of differences among stimuli. These changes were predicated on the assumption that the subjects did not have available a ready set of cognitive structures within which to manipulate the rather novel stimuli in the original conditions.

In other words, it was assumed that the initial low performance was not due to any lack of recognition of the differences among the stimuli but was a product of an inability to organize the material for efficient recall. This assumption was tested by the modified conditions which provided structure in the form of "anchor points" for the range of stimuli.

B. Experimental Procedures

1. Subjects. A total of 378 students from the fourth and sixth grades from the Archdiocese of Detroit School System served as subjects.

2. Materials. Stimulus items were generated from a white noise produced by an Allison 21b audiometer and filtered through a Brüel & Kjaer 2112 audio-frequency spectrometer. Conditions 1A and 1B used 1/3 octave bands of noise centered at 630, 800, 1000, 1250, 1600, 2000 Hz. These are 1/3 octave apart, re 1000 Hz. Conditions 2A and 2B used 1/3 octave bands, 2/3 octave apart. These were centered at 400, 630, 1000, 1600, 2500, and 4000 Hz.

The responses were the letters H, L, M, P, Q, and X for Conditions 1A and 2A. The responses were assigned in sequence to the six stimuli, H to the lowest and X to the highest. However, the subjects were not informed of this relationship nor did any indicate awareness of it during the testing.

For Conditions 1B and 2B, the set of stimuli were the same as for the corresponding "A" conditions. The set of responses, however, were the numbers 1 through 6, assigned by the subject to correspond to the ordinal relationships among the stimuli with 1 assigned to the lowest and 6 to the highest band of noise.

3. Procedure. For Conditions 1A and 2A, standard paired-associate procedures were used. Stimuli were randomly presented during the 10 learning trials as well as the 10 test trials. Three different orders were used for each; learning and test trials did not duplicate one another. During a learning trial the stimulus

items were presented for 3 sec followed by a 3 sec period during which the response was given once. On a test trial 3 sec were allotted for recording of a response in the test booklet.

In all learning trials of the "B" conditions the six stimuli were presented in an ordinal manner, from highest frequency band to lowest or vice versa. The two sequences were alternated. No response was given but subjects were instructed to covertly assign numbers to the stimuli corresponding to their rank. The examiner orally assigned the ranks on the first few learning trials to aid the subjects. No alteration was made of the test trials; i.e., the same random orders as in the previous conditions were used. During a test trial the subject was asked to respond with the rank, 1 through 6, of the test stimulus when presented. The Ampex-Fisher speaker system was used to present the conditions.

C. Results and Discussion

The mean correct responses, standard deviations, and sample sizes for the four conditions and two grades used in this experiment will be found in Table 12.1.

A test for differences between "1" and "2" conditions indicated no significant ones (all t values were less than 1). Thus, the conditions were pooled over frequency differences but not over grades or procedural differences. This finding was somewhat startling in view of the fact that the frequency span of the "1" conditions was 1370 Hz while that of the "2" conditions was 3600 Hz. It would seem that the stimuli in Condition 1 were already spaced sufficiently

Table 12.1. Means and standard deviations of the number of correct responses, by conditions and grades, as well as pooled values for grades.

Conditions		Grades			
		4	4#	6	6#
1A	$\bar{X}$	11.49		15.22	
	SD	7.46		6.61	
	N	71	11.15	64	15.67
			7.04		7.58
2A	$\bar{X}$	10.31	100	15.98	157
	SD	5.90		8.08	
	N	29		93	
1B	$\bar{X}$	17.75			
	SD	7.83			
	N	80	18.24		
			7.73		
2B	$\bar{X}$	19.20	121		
	SD	7.53			
	N	41			

# A or B conditions pooled by grade level.

apart such that additional separation of stimuli did not facilitate discrimination, and hence, performance.

After examination of the A conditions, the B conditions were generated. This was done to determine if performance could be facilitated to the level attained in the "A_1" conditions of Part I of this project. In that earlier work, mean performance in the "A_1" conditions was on the order of 20 correct responses for 10 trials for fourth-grade subjects. A cursory examination of Table 12.1 indicates that performance in the present experiment was below the previous results. This discrepancy is most likely due to the highly distinctive stimuli used in the earlier work. A_1 stimuli differed along many dimensions while the stimuli in the present study differed only along the dimension of frequency. As can be seen in Table 12.1, the B conditions produced a performance level of 18.24 which compared favorably with the mean of 20.40 for the fourth grade with "A_1" condition in Part I. These alterations in the procedure provided significant improvement in performance in the fourth grade ($z = 7.14$; $p < .005$). As an alternate comparison, the fourth-grade B conditions were significantly better than the sixth-grade A conditions ($z = 2.07$; $p < .05$).

To review, the B conditions provided two aids for the subject to use in learning which were not available in the A conditions. First, the presentation of the stimuli to be learned in an "A" condition was random and, in our personal experience, rather chaotic. While it was apparent that the tonal characteristic was changing, it was difficult to provide structure among the items to be learned. The B conditions provided for the orderly presentation of materials such that direct comparisons could be made among adjacent stimuli. The second change provided for an orderly relation between stimuli and responses. As mentioned before, while there was a relation between the alphabetical sequence of the letter responses and the frequency order of the stimuli, no subjects became aware of the relationship, as indicated by post-experimental inquiries. The use of numbers, on the other hand, provided for a more direct stimulus-to-response relationship and required that the subject manipulate the relationship during learning. He could not passively accept the response provided by the apparatus since the apparatus provided none.

It should be recalled that the test trials remained the same in both A and B conditions and that no tenable argument can be made (in our opinion) that a set of letters is more available than a set of numbers.

D. Summary and Conclusions

This study was designed to determine the relationship between learning and inter-stimulus differences. It further explored the effect of structuring the task upon performance. The results indicate that the former had little effect and the latter, a great effect upon learning.

It seems clear that the inter-stimulus differences employed in this particular study do not allow the description of performance as a function of intralist similarity, as has been demonstrated with visual presentations of alphabet materials (Experiment XI). More exciting is the fact that parameters unrelated to the physical aspects of the stimuli were manipulated with a dramatic facilitation of performance. This orientation, of trying to facilitate learning of a particular set of materials, is fairly novel in the field of verbal learning. Previously, the emphasis was placed on rating materials as a function of other parameters, such as association value.

Up to this point, the present series of experiments has explored association value *per se*, formal similarity, pronounceableness, modality, and meaningfulness as *a priori* indices of learning performance. In some cases, notably pronounceableness and "qualitative" meaningfulness (trigrams versus nouns), clear cases were made for the predictability of performance. On the other hand, "quantitative" meaningfulness, association values, did not prove to be a suitable predictor. Modality has been shown to be dependent upon the nature of the materials; some materials cannot be communicated by either channel without change. In addition, modality seems to interact with grade level (Cooper and Gaeth, in press; Gaeth, 1960; 1963; Day and Beach, 1950). Formal similarity has proved useful although there are clear indications that the degree to which the subject is able to structure and abstract from the stimulation is a relevant factor. This experiment attempted to define the inter-stimulus differences which would allow description of auditory material in terms of formal similarity. As in the case of Experiment XI, it was inferred that the subject's ability to structure and abstract was playing an important part in performance. With modifications which facilitate structuring and abstraction, concomitant increases in performance were noted.

It seems clear that the problem faced by the subject is less one of adjusting to increasing similarity among stimuli than it is of selecting relevant parameters and fixing these into some sort of properly indexed memory file. The B conditions successfully created such a system of sorting and filing. The implication for teaching the hearing-handicapped may be tenuous but it is suggested that the dominant aspect of providing amplification for the hearing-handicapped child is his ability to handle the influx of novel stimulation. From the data it may be inferred that questions concerning the manner in which movel stimulation is introduced are more important than the question of whether amplification should be used to provide the hearing-handicapped child with auditory stimulation.

Experiment XIII

Meaning and a Context of Utility

ABSTRACT. An attempt was made to separate conceptually the constructs "meaningfulness" and "meaning", the first being related to traditional indices of associative strength, the second to the occurrence of a "context of utility". The experimental condition consisted of instructions designed to create such a "context of utility" by placing number-CVC pairs in a foreign language context such that the CVC was the name or label for the number in that language. Subjects were fourth-, fifth-, and sixth-grade students. Homogeneous lists of low, medium, and high association-value CVCs were learned under experimental or control (standard paired-associate) instructions by different groups of subjects from each grade. Results indicated that the experimental condition facilitated performance for the medium, but not the low or high association-value lists. Significant conditions x grades and grades x lists interactions were discussed in terms of hypothesized developmental changes in the language context of subjects at different grade levels.

A. Introduction

Numerous attempts have been made to relate meaningfulness to such things as association value, frequency of occurrence, and pronounceableness (c.f., Underwood and Schulz, 1960). Such formulations of the construct of meaningfulness have been fruitful in the sense that they allow some degree of empirical predictability.

In the traditional framework, association value, frequency, and pronounceableness are considered indices of prior processes necessary to produce stable associations. Association value is taken as a rough index of number of associates to a term and this is then related to the probability that a stimulus and response can be hooked together, either directly or through some mediational chaining process. Frequency of occurrence is usually thought to increase the probability of the term through the integration of letters or other units, presumably reflecting still another associative process. Thus, it can be seen that "meaningfulness", as traditionally considered, is a general label for the occurrence of learning (associative) processes prior to the specific learning task at hand. Considered in this manner, the manipulation of "meaningfulness" in a learning task is the provision of various degrees of prior learning.

It can be seen that the traditional indices of "meaningfulness" are neither completely separable from each other nor from the learning process they are used to explore. Further, some confusion between the conceptual and operational status of indices is reflected in the language of some theorists. As Johnson (1962) has pointed out, the construct "M" used by Underwood and Schulz (1960) is used interchangeably to denote both meaningfulness and association value. In general, the variable hypothetically related to meaningfulness has only one criterion for acceptance: demonstrated change in learning with manipulation of the variable. Thus, Underwood and Schulz (1960), after manipulating frequency in several lists and finding no relationship to learning, temporarily ban frequency from "M", saying "the apparent causal status of M derives from a certain amount of covariation with pronounciability...." (p. 192).

It is here proposed that two constructs, "meaning" and "meaningfulness", be distinguished, with "meaningfulness" restricted specifically to indices of prior learning which correlate with present learning situations. So considered, "meaningfulness" has a conceptual status different from learning only on the time dimension.

It would seem that if a construct "meaning" is to have a conceptual status different from learning, the relationship of some variable to learning must be considered necessary but not sufficient for inclusion in the construct. Similarly, the failure of one operational definition of a variable to relate to learning cannot be considered sufficient grounds to exclude that variable from the construct of "meaning". The definition of the units of variables related to meaning and learning is of crucial importance in this regard. The attempt of Underwood and Schulz (1960) to define the unit as written frequency of single-letter occurrence failed to relate to learning and on this basis was rejected from the construct "M". However, as Johnson (1962) has demonstrated, frequency is an important variable when the unit is re-defined to be the frequency with which trigrams appear as syllables of English speech.

The purpose of the present study is to explore the possibility that "meaning", if it is anything other than some kind of previous learning as indexed by association value, frequency, or pronounceableness, is the occurrence of a context of utility. By context of utility is meant a frame of reference or field in which parts are organized, differentiated, and integrated, providing the potential for useful response. Language provides such a context of utility through grammatical and syntactical structure and through the "reference function" of words by which a label refers to and symbolically stands for the thing. Experimental work of Ladefoged and Broadbent (1960) appears relevant in this regard. Using various sequences of auditory stimuli, these authors present evidence that auditory stimuli are grouped for response rather than recognizing each successive sound simultaneously. They also suggest that the subject attends to that class of stimuli which he estimates has a high probability "that some member of the class is about to occur which will convey information essential for a response". This seems to be indirect evidence that context cannot be ignored in the definition of the response unit and that utility is important in the provision of context.

In operational terms, these concepts were experimentally applied through the provision of instructions designed to place a paired-associate task within an established language context having utility for communication. Specifically, experimental subjects received instructions designed to make the task the learning of an organized S-R unit reflecting numerical and verbal equality in a foreign language. Numbers and their verbal labels are presumed to have utility for all subjects, and by providing the relevant instructional set, it is hypothesized that a context of utility will be formed whereby the task is not taken primarily as formation of "connections" or "associations" between separate or isolated components, but the reliable recall of two organized parts within a stable whole having utility for the organism. Comparison of experimental groups with control groups who received standard paired-associate instructions is expected to indicate superior performance for the experimental groups.

B. Experimental Procedures

1. Materials. Three lists of five S-R pairs were used. These lists were drawn from the extremes and midpoint of a set of seven such lists originally constructed to systematically explore the relationship between association value and learning (Experiment IX). Stimulus materials did not vary for all lists, consisting of the numbers 4 through 8. Responses were nonsense syllables selected from fourth- to sixth-grade norms of 100 of Archer's (1960) CVC trigrams. The collection of these norms is described in detail in Experiment VII. The three lists used spanned 10% ranges of these fourth- to sixth-grade norms from 16-25% (low), 46-55% (medium), and 76-85% (high) association values. Table 13.1 gives the response items and association values for these lists. Letter duplication within a list was minimized, only one vowel being duplicated in each list.

2. Subjects. Subjects were fourth-, fifth-, and sixth-grade students from the Archdiocese of Detroit School System. They were tested in classroom groups. For the fourth and fifth grades, at

Table 13.1. Response item lists and association values from grade 4-6 norms.

Association Value Range					
Low		Medium		High	
LYX	16	BIF	46	GAN	77
DAQ	17	ZOT	49	MUF	78
SIJ	19	CUX	51	DOR	81
VAF	23	NEV	53	JAZ	83
GEC	24	HUK	54	PIL	84

least two groups were tested for each condition. Sample sizes were randomly reduced to equal N within each grade to facilitate statistical analyses. Total subjects numbered 501.

3. Procedure. The paired-associate lists were presented visually on a screen, projected from a Tel-n-See machine. Alternate learning and test trials were given for 10 trials. During learning trials the stimulus appeared for 2.5 sec immediately followed by the response for 2.5 sec. The inter-pair interval was 2.5 sec. During test trials the stimulus appeared for 2.5 sec and 5 sec were allowed to write the response in test booklets.

These parameters are exactly the same, as are the materials, as those used in Experiment IX. Corresponding conditions from that study provided data for "control" conditions, in that the only procedural difference between the two sets of data is in the instructions. Standard paired-associate instructions were given to control groups, from Experiment IX. Subjects in experimental groups were also given these instructions, but prior to this they were told: "We're going to show you some numbers and the names of these numbers in a language called Swabezi. Your task will be to learn what the names of these numbers are in this foreign language." After the standard paired-associate instructions were given and just prior to the first learning trial, the experimenter said, "Remember, you will see a number and then the name of that number in Swabezi. You are to learn what these names are so that you can write them down in your booklet on the test times."

C. Results and Discussion

Table 13.2 presents the mean performance and standard deviations for experimental and control condition at each level of association value for the three grades.

Table 13.2. Means and standard deviations of the number of correct responses for the three lists, by conditions and grades.

Grades	Conditions		Association Value of List		
			Low	Medium	High
4	Exp.	$\bar{X}$	18.14	29.80	36.25
		SD	11.31	14.16	9.07
		N	64	64	64
	Con.	$\bar{X}$	15.41	21.70	26.08
		SD	12.14	11.58	13.48
		N	64	64	64
5	Exp.	$\bar{X}$	26.95	34.73	33.13
		SD	12.09	10.43	11.15
		N	64	64	64
	Con.	$\bar{X}$	23.59	26.39	32.76
		SD	13.24	8.93	13.08
		N	64	64	64
6	Exp.	$\bar{X}$	29.85	31.38	33.95
		SD	12.20	11.64	9.18
		N	39	39	39
	Con.	$\bar{X}$	33.62	33.82	38.87
		SD	10.68	10.20	9.81
		N	39	39	39

For clarity, the means in Table 13.2 are presented graphically in three figures by grade level. Figure 13.1 (p. 190) presents mean performance of the experimental and control conditions at the three

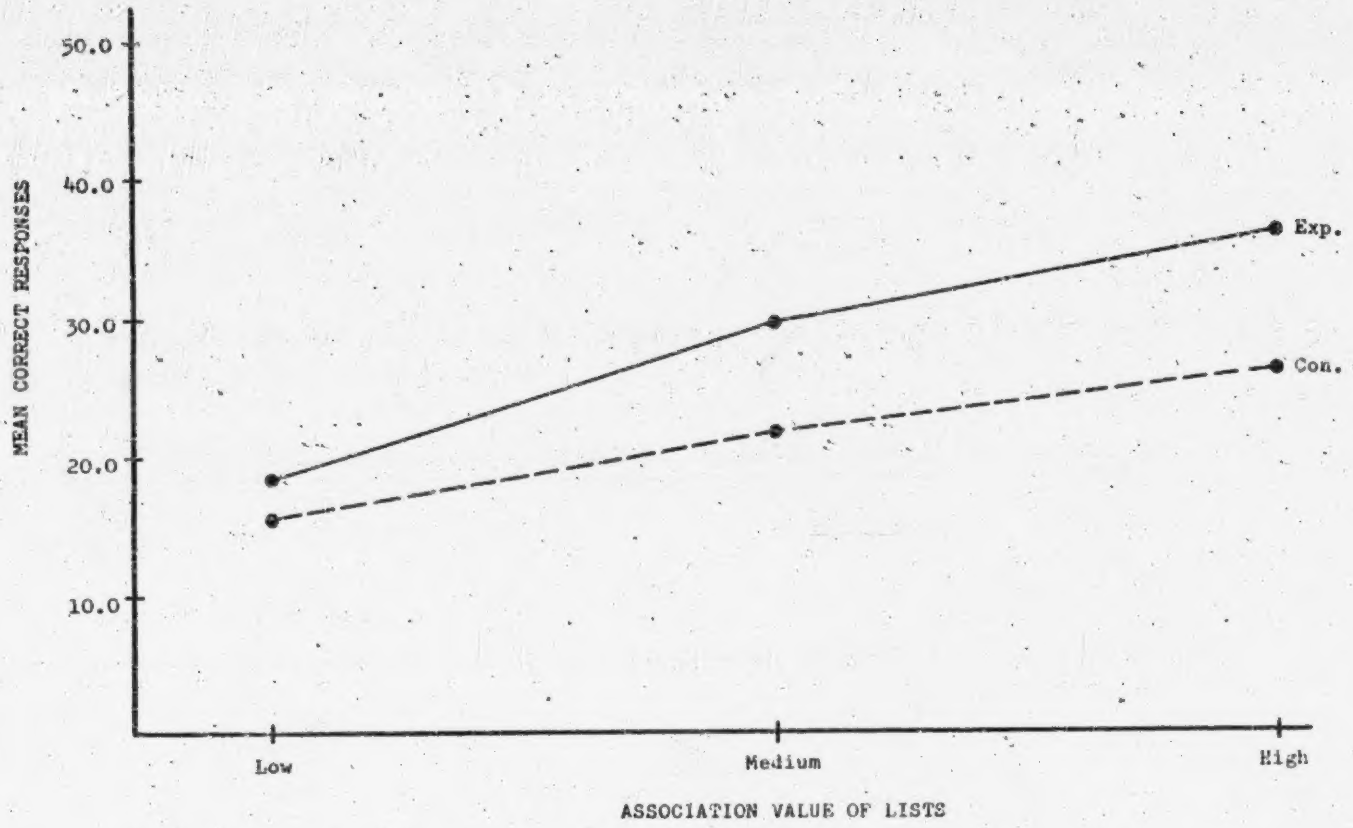


Fig. 13.1 Mean correct responses for experimental and control conditions in grade 4; by levels of association value.

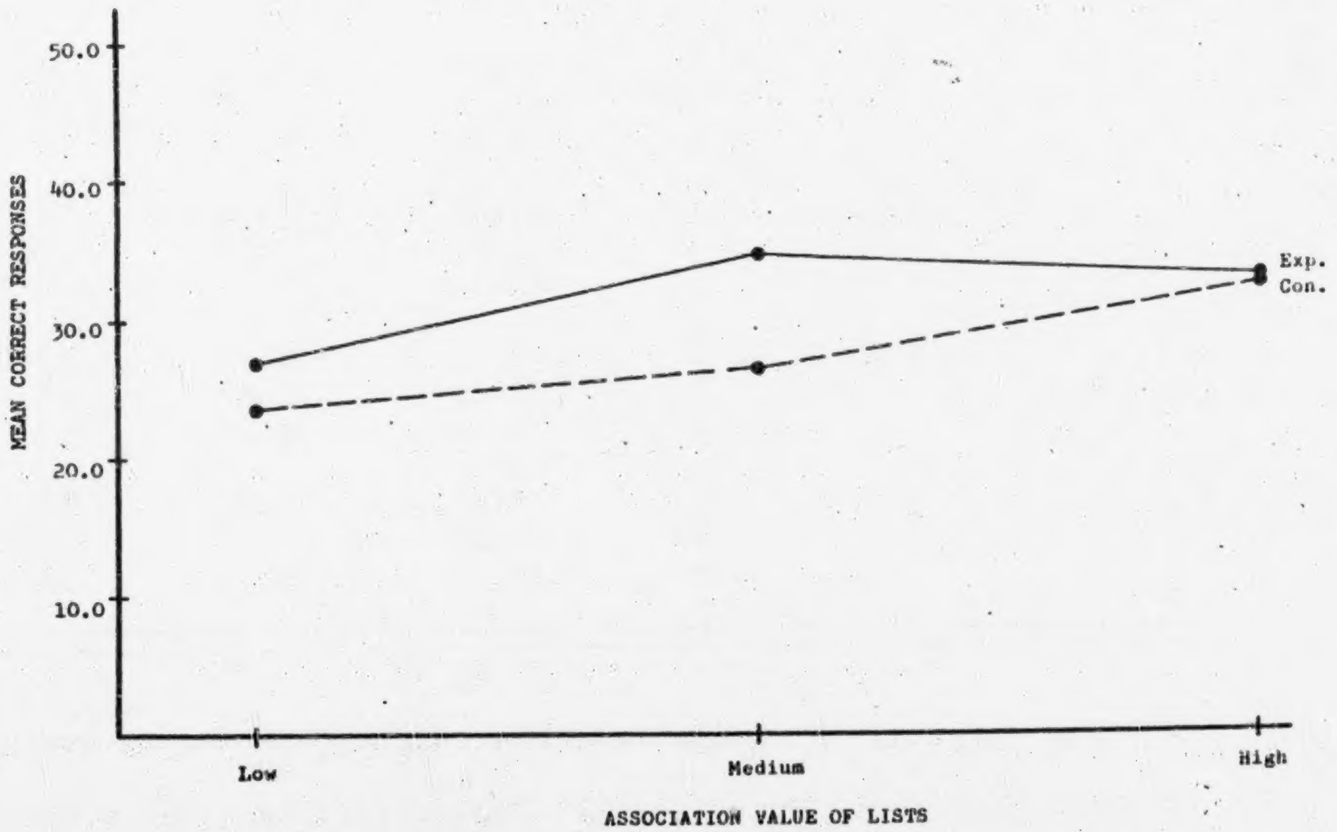


Fig. 13.2 Mean correct responses for experimental and control conditions in grade 5; by levels of association value.

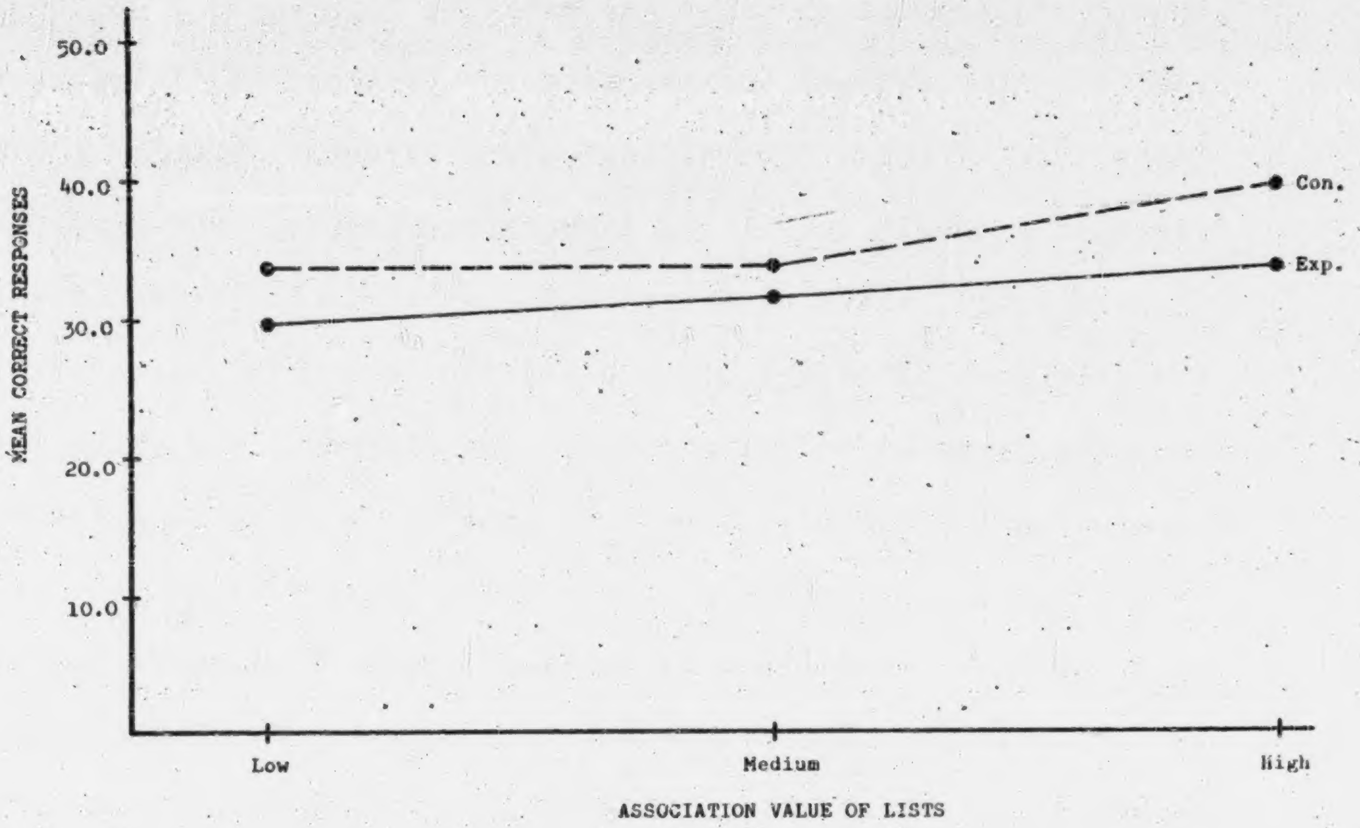


Fig. 13.3 Mean correct responses for experimental and control conditions in grade 6; by levels of association value.

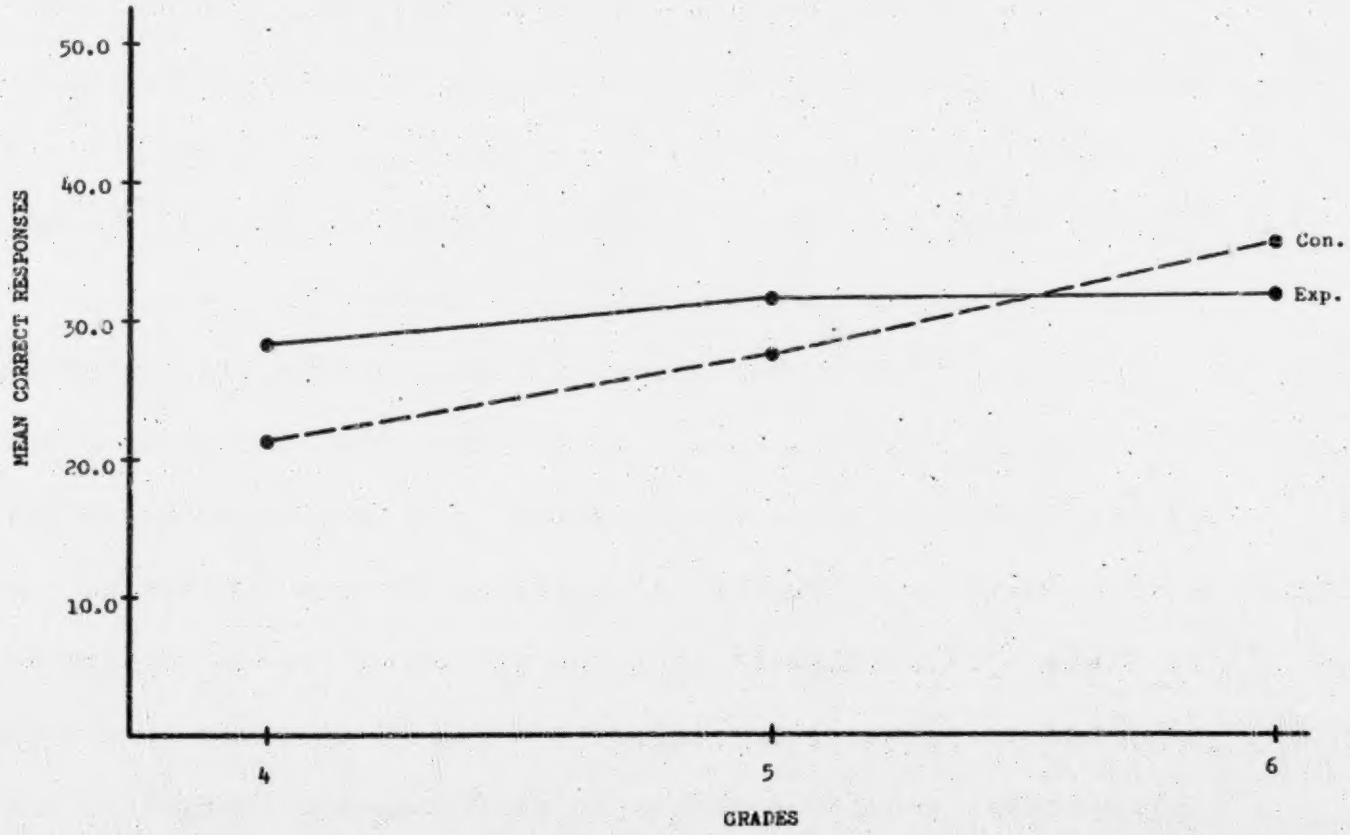


Fig. 13.4 Mean correct responses for experimental and control conditions across three levels of association value; by grades.

levels of association value for grade 4; Figures 13.2 (p. 190) and 13.3 (p. 191) present similar data for grades 5 and 6, respectively. Inspection of these figures indicates different effects of the experimental conditions at the three grade levels. For grade 4 (Figure 13.1), there seems to be a general facilitative effect of the experimental over control conditions which increases with increasing association value of the list learned. For grade 5 (Figure 13.2), the experimental condition appears to facilitate performance at low and medium levels of association value, but to have no effect with the high association value list. Grade 6 (Figure 13.3) reverses the trend of the other two grades, with the experimental condition resulting in a rather consistent decrement in performance in comparison with the control condition at all levels of association value.

These inconsistencies, as well as others in the data in Table 13.2 are supported by a three-way analysis of variance summarized in Table 13.3. Two of the two-way interactions are statistically significant ($p < .01$) disallowing any general statement about the main effect of conditions, grades, or lists.

The significant conditions x grades interaction is graphically presented in Figure 13.4 (p. 191). This figure indicates the expected trend for better performance with increasing grade level for both conditions. However, an analysis of simple effects, summarized in Table 13.4, indicates that the effect of grades is significant only for the control condition ($p < .01$). It would seem that the experimental condition increased performance primarily in the fourth grade, while perhaps reducing performance in the sixth grade, thus

Table 13.3. Summary of the analysis of variance for two conditions, three lists, and three grades.

Source	df	MS	F
Conditions (C)	1	705.14	5.27*
Grades (G)	2	6462.23	48.28**
Lists (L)	2	6321.16	47.23**
C x G	2	2417.87	18.07**
C x L	2	318.82	2.38
G x L	4	765.52	5.72**
C x G x L	4	268.98	2.01
Within Cell	984	133.84	

** $p < .01$.
 * $p < .05$.

reducing the differences between grades. This interpretation is supported by the analysis of the simple effects (Table 13.4) of conditions for each grade. Only in the fourth grade does the experimental condition result in a statistically significant ($p < .01$) increase in performance. Although the experimental condition tends to result in a decrease in performance for the sixth grade, this trend is not statistically reliable.

The significant grades x lists interaction is presented graphically in Figure 13.5 (p. 195). This figure indicates that the effect of grades is greater at low than at medium or high association value of the list, thus accounting for the significant interaction. However, the analysis of simple effects (Table 13.4) indicates that the effect of lists for all grades and the effect of grades for all lists are significant in all cases ($p < .05$).

The nonsignificant conditions x lists interaction indicates a

Table 13.4. Summary of the analysis of simple effects for the three two-way interactions.

Source - Simple Effects	df	MS	F
Of Conditions for			
Grade 4	1	1292.66	9.55**
Grade 5	1	428.59	3.16
Grade 6	1	439.17	3.24
Of Grades for			
Experimental	2	230.17	1.74
Control	2	2891.64	21.86**
Of Lists for			
Grade 4	2	2795.08	21.13**
Grade 5	2	817.49	6.18**
Grade 6	2	416.68	3.15*
Of Grades for			
Low A.V. List	2	2978.95	22.52**
Medium A.V. List	2	654.79	4.95**
High A.V. List	2	468.27	3.54*
Of Conditions for			
Low A.V. List	1	55.56	.41
Medium A.V. List	1	869.08	6.41*
High A.V. List	1	181.22	1.34
Of Lists for			
Experimental	2	1519.90	11.49**
Control	2	1111.15	8.40**

** $p < .01$.
* $p < .05$.

trend for the experimental condition to result in better performance at all levels of association value of the lists. The analysis of simple effects (Table 13.4) indicates that the effect of conditions is only significant ($p < .05$) for the medium association-value list. Since each point is pooled across grades, this finding reflects a

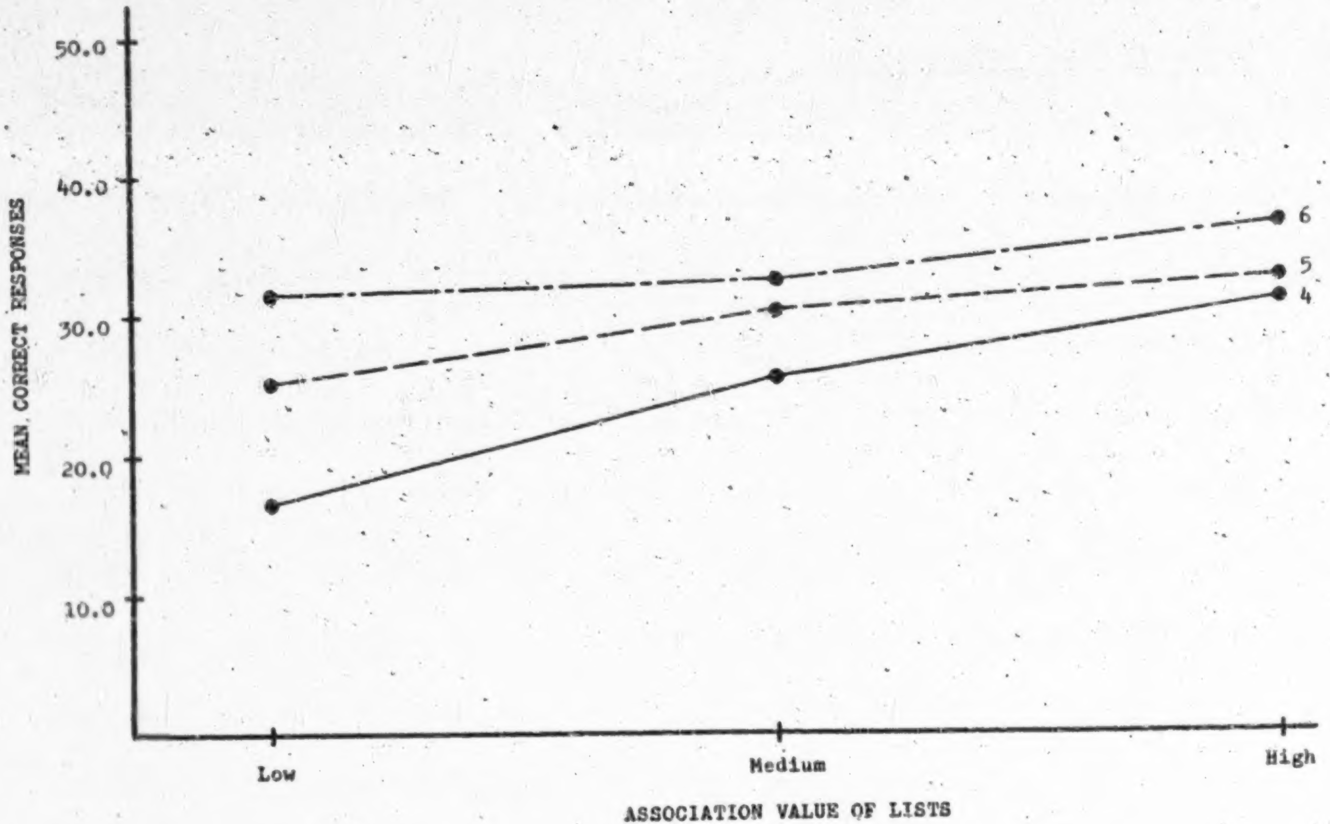


Fig. 13.5 Mean correct responses for grades across experimental and control conditions; by levels of association value.

tendency for the experimental condition to facilitate performance with the medium association value for all grades, while at low and high association values the experimental condition tends to have different effects for different grades, including a tendency to debilitate performance in the sixth grade. The analysis of simple effects (Table 13.4) also indicates a significant tendency ($p < .01$) for performance to increase with increasing association value of the list for both conditions. It will be recalled that the range of association values for CVCs in this experiment is 68%. The significant effect for association value is in line with the findings of Experiment IX.

D. Summary and Conclusions

The significance of the interactions obtained can only be hinted at with indirect evidence for speculations. The ideas presented below are post hoc, although as general phenomena concerning language as an autonomous field (Vigotsky; Cassirer); or as the progression of development through sensory-motor, to functional, to abstract-conceptual levels of organization (Piaget; Werner); and the importance of differentiation in learning (Gibson, 1940; Saltz, 1963a), they are well documented in the literature. The *a priori* expectations were simply (1) that the creation of a "context of utility" might be a greater aid to younger than to older children due to the younger child's greater plasticity and spontaneity and to the competition with the older child's more dominant English language conceptual framework, and (2) that as the material to be learned became increasingly like "nonsense" (i.e., less assimilated to experience in either sensory or language spheres), the provision of a "context of utility" would be increasingly effective. These two expectations lead to the predictions of (1) a conditions x grades interaction with increasing effect of the experimental condition with decreasing grade level, (2) a conditions x lists interaction with the experimental condition having increasing effect with decreasing association value of the list, and (3) no lists x grades interaction. The third prediction would reflect both of these trends, the effect of association value decreasing with increasing grade level while the effect of the experimental condition increases in a compensatory fashion with decreasing grade level.

The predictions outlined above are only partly supported. The conditions x grades interaction is significant and in the expected direction, the experimental condition having the greatest effect in the fourth grade.

The conditions x lists interaction is not significant; there is no difference between experimental and control conditions for the low association value list where the greatest facilitation was expected. The experimental condition does, however, result in significant facilitation for the medium (but not the high) association-value list.

The grades x lists interaction is significant contrary to the prediction. This interaction was obtained also in Experiment IX of this report in which seven lists sampling a wide range of association values were administered with standard paired-associate instructions to different groups in the fourth, fifth, and sixth grades. Data from the middle and two extreme lists are used for the control conditions of the present experiment. In general, association value was found to make surprisingly little difference in performance, especially in the sixth grade, but to have increasing effect with decreasing grade level. Since this (significant) interaction cannot be attributed to differences in association value norms for the different grades (see Experiment VII) or to the approach of asymptotic performance, more general differences in the subjects at different grade levels must be sought.

The data can be fit into the present conceptual framework concerning "meaning" in the following manner. Since the grades x lists interaction occurs within the control condition as previously described, it is tentatively suggested that the effect of developmental level (as indexed by grades) outweighs the effect of the experimental attempt to create a "context of utility". It is hypothesized that the active subject assimilates the learning material to his dominant context of utility and that these contexts are different for subjects in different grades. For sixth-grades students, the context is the English language, and CVCs become syllables in some form. As syllables, the material in all lists becomes functionally equivalent in terms of being sub-units to words. Although idiosyncracies as to specific relationships would be considered the rule, for sixth-graders it is hypothesized that CVCs in all lists become English syllables subordinate to, and assimilated to, English words. Moving toward the fourth grade, however, it is suggested that the CVCs become "nonsense"; that is, not ordinarily related to anything in sensory or language experience. When forced to relate the CVCs to something (as in the collection of association value norms), fourth-grade subjects probably relate them to various things, some of these things being words, others being objects or memories, et cetera. But the kind of relationship is probably much different for younger than for older children. In cases where younger children relate the CVCs to words, the similarity is probably on the basis of visual or auditory similarity as such and not subordinate to and assimilated to words as in the older children (i.e., physical similarity, not conceptual).

Given these speculations, which could be best studied by a qualitative analysis of errors, children at different age levels have different pre-existing contexts of utility. For older children such a context is primarily a language context in which words "stand for" relationships and sensory-motor experience is assimilated to language. For younger children the context is primarily one of action in which words indicate direction and intensity of movement as such (c.f., Piaget; Werner).

Considered in this light, the experimental instructions provide a different context for the younger children, a way to "do things" in another country; i.e., emit names for numbers. In contrast, for the older children the instructions may be thought to produce a competing context, a language context incompatible with the dominant English language context; i.e., a different way to represent relationships.

This interpretation, of competing language contexts, would explain the general tendency for the experimental condition to debilitate performance in the sixth grade while facilitating performance in the fourth grade. In the fifth grade, the high association value list might be thought to compete with the language context while the middle association value list is not similar enough to do so.

This does not, however, explain the lack of facilitation by the experimental conditions of the low association value list for the fourth and fifth grades (see Figures 13.1 and 13.2, respectively). Assuming increased conflict with the language system as association value increases, the effect of the experimental condition should increase with decreasing association value of the list. This, however, does not happen in any grade. In the fourth grade (Figure 13.1) the difference between experimental and control conditions increases with increasing association value of the list; that is, the reverse of the expected relationship. Similarly, the conditions x lists interaction would be expected to be significant, with the largest experimental-control difference for the lowest association-value list. As previously indicated, no such difference was found, although there was a significant experimental-control difference for the medium association-value list.

It is possible to speculate that such relationships occur due to the operation of an additional variable, that of response differentiation. Viewed in this manner, the instructions used would tend to produce two partially incompatible results; a "context of utility" in which pairs of things suddenly "go together", but also a context in which some of the elements (CVCs) become more alike, a set of "names for numbers". It is assumed that parts of the language system can produce generalization effects (Razran, 1952), without the language system as a whole becoming dominant and inflexible. Presuming that the association-value index of "meaningfulness" includes a response differentiation component, with low meaningful CVCs less differentiated than highly meaningful ones,[1] any loss in differentiation due to instructions would have a greater decremental effect at low than at high association value. Within this framework, the effect of instructions for the younger children would be to reduce differentiation below a critical level in the low association-value lists, thus eliminating the beneficial effects of increased "meaning". The lack of such effects in the sixth grade would be due to the overall dominance of the English language context which precludes the formation of a new context with the instructions employed.

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[1] Such a hypothesis is testable by putting each CVC in homogeneous lists of different association value in a distinctive color background. Saltz (1963b) has shown this procedure to facilitate performance. The greatest facilitation should occur for the list with lowest association value.

While much of the above formulation is speculative, it is believed that the hypotheses are testable through the manipulation of different instructional settings, qualitative error analysis, and the effects of known differentiation procedures on lists of different levels of association value. Hopefully, such research would tend to dispel the mystique of "meaningfulness" as traditionally indexed, as a stable, almost immutable indicant of previous, and therefore present, learning, and lead the way to the processes which influence learning itself.

SUMMARY AND CONCLUSIONS

A. Background

The present project is a continuation of research into verbal learning initiated in 1957 among children with hearing handicaps. From 1957 through 1960, the research was primarily concerned with the effects of modality of presentation upon the learning of meaningful material. Data were accumulated for both hearing-handicapped and normal-hearing children. The latter group was necessary in order to obtain normative information to gauge the performance of handicapped children. The results of that project indicated that with normal-hearing children and meaningful material, little difference in performance was obtained as a function of sensory mode of presentation. It also suggested that a plateau in performance was reached at about grade 6 with little improvement as a function of grade or age beyond that. With hearing-handicapped children, the results indicated that they perform almost as well as normal children with visual or combined audio-visual presentations but, as would be expected, performance was drastically reduced with an auditory presentation.

A point of great interest in the performance of both groups of children is the fact that the combined audio-visual presentation was not better than the best of the two single-channel presentations. The conclusion appeared to be that a combined presentation is beneficial only in that it allows each subject freedom to select one of the modalities for learning; no additional cues for learning are available in the combined presentation than are present in the best unimodal presentation of the same material.

In 1960 a second research project was begun, to continue until 1963. That investigation and the present one, initiated in 1963, constitute methodical explorations of variables relevant to the problem of verbal learning. The original project, just described, might be viewed as a pilot study for this body of research since many of the parameters subsequently investigated were suggested by results of the first project.

The second study, 1960-63, extended the scope of materials to be learned to cover nonmeaningful and nonverbal material and also used a wider age range of subjects. It had been thought that the findings of the initial project might be a function of the highly meaningful material used. By exploring performance with other kinds of material, the generality of those findings could be tested. The major results of the second project revealed that, again, the combined presentation was no better than the better of the two unisensory presentations regardless of the class of material being learned. It further indicated that the modality attended to in a bimodal situation is that which is more meaningful. For normal-hearing subjects the more meaningful channel is determined by the material; for hearing-handicapped children, the visual modality is always more meaningful. Widening the range of materials shifted the plateau in the learning curve up to the tenth grade.

The present project investigated further the variables of meaningfulness and modality preference. The parameters of meaningfulness itself were explored in an attempt to determine how material becomes meaningful. Scaling of verbal items was conducted to quantify some of the results. Since a single modality is apparently selected on the basis of relative meaningfulness when a combined audio-visual presentation is used, the conditions affecting such modality preference were explored. The role of unimodal attention when both modalities must be assimilated to learn was also studied. These, then, are the general purposes of the present project.

B. Objectives

The major goals of this project are to 1) define "meaningfulness" or the dimensions of meaningfulness in children, 2) to study the relationship of meaningfulness to sensory channels of presentation, and 3) to relate the findings to the education and training of normal and hard-of-hearing children.

Answers to the following types of questions were expected from analyses of the data:

a. How important is the discriminability of the items in a learning task? Is learning faster with greater discriminability?

b. Does similarity of meaning or similarity of symbolization cause more interference? Can the effect of similarity in one channel be overcome by dissimilarity in the other sensory channel?

c. Is pronounceableness an important item in verbal learning? Assuming equal associative values, will pronounceable material be easier to learn than nonverbal material? What is the effect of subvocal pronunciation on learning?

d. Given a complex learning task, will the subject do better if he learns components of the task first or if he is faced with the entire task right from the start?

e. How flexible is the phenomenon of modality preference? Does bimodal attention occur if the situation demands it?

f. Do subjects with moderate hearing losses perform more like normal or like "deaf" subjects in a bimodal situation? That is, do they respond to meaningfulness or to modality?

C. Procedure

1. Apparatus. The basic equipment used in the project consisted of a slide projector coordinated with a tape recorder for the presentation of learning materials. The Ampex-Bell & Howell system developed in the second project was used along with a newer instrument, the Tel-n-See. The major difference between the two systems is in the presentation of visual material, slides being used in the older system and a film strip in the newer. Both systems utilized pulses recorded on one channel of the magnetic tape to activate the projector.

2. Materials. A wide variety of materials was needed in this study to accomplish its purposes. The specific materials generally fell into one of the three classifications formulated in the previous project, namely, nonmeaningful-nonverbal, nonmeaningful-verbal, and meaningful-verbal materials. The same notations were used to avoid confusion. The numbers 1, 2, and 3, respectively, were assigned to the three levels of materials. Letters A and V indicated sensory channel of presentation. Thus, the notation A_1 indicates nonmeaningful-nonverbal material presented auditorily, while A_3V_2 means a bimodal presentation with meaningful-verbal material in the auditory channel and nonmeaningful-verbal material in the visual. Wherever it

was reasonable, these kinds of notations were used to aid in identifying the experimental conditions. Specific notation was introduced when this system was inappropriate.

3. Subjects. All testing of normal-hearing children was done in classroom units. Children in grades 4, 5, and 6 of the Detroit Public School System or the Archdiocese of Detroit School System were used for the bulk of experimentation. A sample of hard-of-hearing children in the metropolitan area was tested in small groups. In addition, data were obtained from children in a residential school for the deaf. In all, more than 9000 children were tested in this project.

4. Procedure. For most of the experiments a recall form of a paired-associate task was used. Usually 10 learning trials alternated with 10 test trials. During a learning trial, each stimulus item was presented followed by its appropriate response. During a test trial, only the stimuli were presented and the subjects were instructed to write down the appropriate responses in turn if they remembered them. Several different orders in which the items were presented for learning and test trials were used. Deviations from this procedure are noted in the specific experiments.

Following the collection of the data, the booklets were scored, tabulated, and summary statistics for the samples calculated to obtain the mean correct responses over a fixed number of trials. Learning curves were obtained by calculating the mean number of correct responses for each trial.

One portion of the study involved the collection of association values for selected trigrams from children. A different procedure was necessary. The trigrams were printed in two columns of 25 each on 8 1/2 x 11-inch pages. Each trigram was followed by "Yes___ No___" for the child to use in responding. A copy of the instructions given orally to the class is presented in Appendix B.

The project was carried out as a series of experiments related to the major goals. The results are divided into problem areas for ease in presentation. The experiments relevant to these areas will be summarized briefly in turn.

D. Results Pertaining to Cooperative Research Project #1001

Two experiments were conducted to clarify the general findings from the previous investigation.

1. Experiment I: Learning of New Nonmeaningful-Nonverbal Material. It had been hypothesized that V_1 material (modified electrical symbols) would produce poorer performance than that obtained with V_2 material which is also nonmeaningful but verbal in nature (CVC trigrams). The trend of the data in the previous project suggested that this hypothesis was not tenable; differences were not significantly but were consistently in the opposite direction.

To determine whether this finding was an artifact of the particular stimuli employed, performance using an additional set of V_1 material was indicated to verify the results. Greek letters were selected as stimuli for this study. All other aspects of the study paralleled those used previously.

The results were consistent with the "old" V_1 material, even to the point of clearing up the single reversal obtained previously (grade 4 had been the only exception from five grade levels to the trend of V_1 scores being higher than V_2). It was concluded that the slightly superior performance with V_1 material was not a function of the particular items used but was a verifiable finding capable of generalization.

2. Experiment II: The Relationship Between Bimodal and Unimodal Presentation with Material Variables Manipulated on the Response Side. The project preceding this indicated that a combined audio-visual presentation was not superior to the better unimodal performance. Before this result is generalized it was necessary to determine whether it held when meaningfulness and verbalness were manipulated on the response side. To this point, the studies had employed a constant set of responses and gauged the effect of changes in the set of stimulus items upon performance. Previous work by other investigators had shown that changes in meaningfulness of stimuli or responses produced similar effects with a greater influence noted when response meaningfulness is varied.

The generality of the findings were checked by selecting six conditions from the last project, reversing the stimulus-response pairings, and administering these altered conditions to a new set of subjects. The conditions used were A_2, A_3, V_2, V_3, A_2V_2, and A_3V_3, these being the only ones amenable to such modifications.

The results of this study indicated again that a combined presentation does not facilitate performance over that obtained with the better of the two unimodal conditions.

3. Conclusions. These two experiments verify and extend findings from the last investigation. They indicate that the results can be generalized without undue caution. Experiment I points out also the need for re-examining the hypothesis that a single continuum underlies the three classes of material studied in the previous project. It had been assumed, at the outset, that performance would be better with meaningful than nonmeaningful material and with verbal as contrasted with nonverbal material. Therefore, use of nonmeaningful-nonverbal material should have produced less learning than that obtained with nonmeaningful-verbal material. The data force us to reject this hypothesis.

E. Results Pertaining to Modality Preference

One of the most interesting conclusions of the last project was that meaningfulness determines the single modality receiving the chief attention in a bimodal situation. Further exploration of this finding was conducted to determine the parameters involved. Four experiments pertain to this problem area.

1. Experiment III: Modality Preference. This experiment was conducted in three phases, methodically examining the phenomenon of modality preference in different situations of bimodal stimulation. In all three studies, the subject could master the task to some degree or entirely by attending to only one modality.

Phase 1 utilized the A_1V_1 condition of the last project. Four different groups were tested; each group was interrupted at a different point in the bimodal learning task to determine the relative amounts of auditory and visual learning which had occurred. The specific stimulus materials of this condition were unique for each modality although considered equally nonmeaningful and nonverbal. The results, while not conclusive, suggested a tendency to learn a few of the visual items first and then to attend to the auditory dimension.

Phase 2 used Conditions A_1V_1, A_2V_2, and A_3V_3. Procedure was modified to allow inferences concerning modality preference to be made. All of the learning trials were bimodal; i.e., auditory and visual materials were presented simultaneously. All of the test trials were unimodal presenting the six stimuli from one modality followed by the six stimuli from the other modality. In this way separate scores for the two modalities were obtained from each subject. Comparing these scores indicated a significant difference for A_1V_1 with more visual items being learned. For the other two conditions, no significant differences as a function of modality were obtained. These results suggested that modality preference is most apparent when different materials are used in the two modalities.

The third phase of Experiment III employed different lists of words and different responses in the two channels to verify the results of the previous segment of the study. Simultaneous audio-visual presentation was used for all learning and test trials. In order to synchronize presentations, procedural changes were introduced which confounded the results. Examination of the data after "correcting" for the effect of procedure suggests that material in either modality was learned equally well.

These findings may be an artifact of the procedure and the "correction" factor. If the results have validity they suggest either that no modality preference is obtained with highly meaningful, verbal material or that idiosyncratic modality preference is operating which cannot be detected using group procedures.

2. Experiment IV: Integration of Visual and Auditory Responses into a Single Response in Paired-Associate Learning. This experiment attempted to determine the efficiency of learning a bimodal task as a function of the way the task is presented. Unique stimuli were delivered in the two sense modalities with single digits as responses. With this kind of material, it was possible to present both auditory and visual stimuli simultaneously, requiring a two-digit response, or present the two lists independently with one-digit responses.

Two experimental conditions were used; one, termed "separated", presented the auditory and visual lists independently during the first half of the task and then simultaneously for the last five trials. The other condition, designated "combined", used the simultaneous presentation throughout. The results showed a clear superiority of the "separated" procedure over the "combined" whether performance is compared by blocks of five trials (corresponding to the experimental procedures) or whether overall performance is measured.

3. Experiment V: The Effect of Unimodal and Bimodal Cues Upon Learning. This experiment, like the preceding, was designed to determine the most efficient way to present elements of a complex stimulus for learning. However, one important difference exists between the

two studies. In this experiment, both elements had to be learned as a unit before the correct response could be achieved whereas in Experiment IV each element of the stimulus had its own response. Of particular interest in Experiment V is the effect of presenting two cues simultaneously in the same modality, or simultaneously but in different modalities.

The results clearly indicate that presenting the two stimulus components visually is far superior to any other combination. However, the next most efficient condition used bimodal stimulation, with the meaningful element in the visual modality and the nonmeaningful stimulus component presented auditorily. Thus, no general statement concerning unimodal versus bimodal stimulation was possible; the efficiency of these forms of presentation is apparently confounded with meaningfulness.

4. Experiment VI: Modality and Meaningfulness in Children with Moderate Hearing Impairment. It had been demonstrated that normal-hearing subjects in a bimodal task attend to the channel containing the more meaningful material while severely hard-of-hearing subjects attend to the visual modality only. These findings had import for teaching children who are classified in either group. However, they did not permit recommendations to be made concerning subjects with mild-to-moderate hearing losses. This segment of the population is generally treated as if it were "normal"; i.e., these children are usually placed in regular classrooms with auditory training added to their curriculum. It is assumed that prescription of the proper hearing aid plus training in using it brings these

subjects into the "normal-hearing" population.

In order to test this assumption, several of the same learning tasks given to the other two hearing-ability groups were administered to a sample of children with intermediate hearing losses. Bimodal learning conditions were used with an additional five trials of only the auditory material. Control conditions consisted of 15 trials of only the auditory dimension. The performance of these subjects was then compared with both normal-hearing and "deaf" subjects.

The results of this experiment indicate that groups with intermediate hearing ability perform much like "normals" on these tasks. They use the auditory modality less efficiently, as would be expected, but they do not avoid using this dimension for learning in a bimodal situation. However, these subjects tend to perform at the same level regardless of material and modality manipulations. Normal-hearing and deaf children quickly decide which modality to attend to, given a bimodal task. With the hard-of-hearing subjects, the decision is not made as rapidly. For example, in the condition where the visual modality contains nonmeaningful-nonverbal electrical symbols (V_1) and the auditory dimension contains familiar words (A_3), the "normals" listen and the "deaf" look with the same degree of efficiency as indicated by equivalent performance. The "hard-of-hearing" perform more poorly; analyses imply that they attempt to learn by both modalities, probably sequentially, with a corresponding loss in efficiency since the two modalities do not contain the same material.

5. Conclusions. This series of studies has implications for the education of both normal and hearing-handicapped children. It

emphasizes the fact that disparate materials should not be presented bimodally for learning if at all possible. The task can be mastered much more efficiently if the separate components are dealt with first followed by training in combining them. However, if the materials in the two modalities approach redundancy, no advantage seems to be gained from bimodal stimulation. Either modality is equally as effective as a combined presentation. In cases where the components cannot be separated for learning, these studies suggest that a visual presentation of the multiple components is favored. If the nature of the materials is such that bimodal simultaneous stimulation is unavoidable, then it appears that acquisition of the material occurs more rapidly when the visual modality contains the more meaningful element.

Extending these findings to the problems encountered in developing language skills in the severely hearing-handicapped, it might be more advantageous to present language initially in its many visual forms; e.g., reading, lip reading, and other visual "forms" of the spoken language. After the child has mastered language to some extent in these forms, then the auditory and oral elements can be added. The alternative would be to present the two as separate tasks throughout the early portion of his education, combining them later.

F. Results Pertaining to Association Values

This portion of the project involved the scaling of selected trigrams for meaningfulness by children. Several studies are available for the adult population using these same materials. The basic assumption underlying these tasks is that the proportion of subjects who indicate that an item reminds them of a word is an index of the meaningfulness of that item. Less meaningful trigrams have fewer associations and, therefore, fewer persons would report an association. This procedure has validity to the extent that items so scaled behave in a way consistent with the concept of meaningfulness. Such consistencies have been reported, using adult subjects.

1. Experiment VII: Association Values for Selected Trigrams with Children. Five different studies were conducted using children in grades 4-6 of the public schools and children from a residential school for the deaf. Lists of 50 and 100 CVC trigrams were evaluated by such subjects. The obtained values showed a high correlation with adult values indicating that such norms can be used with younger subjects. These results also lend further support to the use of such values as an index of meaningfulness since it was assumed that meaning to children and adults should differ in degree but not in kind. The values obtained from deaf subjects correlated very highly with normal-hearing children and substantially with adult values. These findings are interpreted as consistent with the assumption that meaningfulness increases with experience; therefore, children at the two levels of hearing ability would and do differ less with respect to this parameter than would either group when compared with adults.

Other aspects of this section of the project investigated areas which did not have parallels with adults. Norms were obtained simultaneously for both CCC and CVC trigrams from the same children. The two kinds of trigrams were presented in isolated blocks, alternated, or randomized. The extremely high intercorrelations among the three forms of presentation suggest that the same criteria were used to evaluate both kinds of trigrams so that they could be arranged along a single continuum of meaningfulness according to their scale values. No data exist previously in the literature to indicate the relationship between scale values for the different forms of trigrams.

Lists of CVCs representing only a portion of the entire range of association values were also administered. The data indicate that scale values are not absolute numerically although the items do maintain their same relative position. This finding has implications for verbal learning tasks which use a truncated list of association values, and then relate the performance to the scale values obtained from an unrestricted list. Effects of such procedures will be presented in a later section of this project. Suffice it to say here that the use of items with extremely restricted ranges of association values for learning shows little relationship with performance. The explanation for this phenomenon lies in the assumption that items in restricted lists are subjectively scaled relative to one another rather than against an absolute standard of meaningfulness. This assumption is derived from the changes in scale values obtained with the use of truncated lists of CVCs as compared with the numerical values assigned when the entire list was evaluated.

One last factor in the examination of the meaningfulness of association values was the effect of prior opportunity for establishing associative links upon association values. A paired-associate learning task was administered with trigrams (CVC or CCC) as responses. Following this task, association values were obtained for lists of both kinds of trigrams among which were included the specific response items from the task. The results indicated that such prior exposure increased the association values for both sets of trigrams with the CVC values being more grossly affected. Performance in the learning task was also better with these items, suggesting that associations are gained or established in the learning process. It might be inferred that the failure to find an association (other than the one provided in the task) for a low meaningful trigram impedes paired-associate learning.

2. Conclusions. The several studies conducted in collecting association values from children indicate that adult values are good indices of children's values when a broad range of CVCs are considered. With restricted ranges of items, the studies with children suggest caution in interpreting items in terms of their "absolute" values. Since children parallel adults so closely, the same warning might apply to adults as well. Data were also obtained bearing upon the relationship between association values for CCCs and CVCs.

G. Results Pertaining to Meaningfulness

The concept "meaningfulness" is still lacking a precise definition but there is no disagreement concerning its relationship to learning. Using changes in performance, then, to indicate changes in meaningfulness, several variables were studied with children as subjects. These particular variables had already been described as relevant to meaningfulness on the basis of studies with adults. Since the concept "meaningfulness" is assumed to be the same at all ages, these studies would serve to validate the parameters already identified. Furthermore, it was hoped that, by studying subjects who are "gaining" meaningfulness, insight might be obtained as to the nature of this process.

The parameters investigated included those of associability, pronounceableness, and discriminability (or its converse, similarity). An attempt was made to generate meaningfulness by associating low meaningful items with highly meaningful ones. The effect of variations in association value was examined. The role of pronounceableness (both implicit and explicit) was studied for its effect upon performance. Similarity was manipulated to determine its relationship to meaningfulness. Finally, meaningfulness was studied with respect to the role that structuring of the task plays in performance. Actual restructuring of the task into a more integrated unit was examined as well as the effect that changes in instructions produce. Each of these was the topic of a separate experiment.

1. Experiment VIII: Production of Meaningfulness by Association. This study attempted to increase the meaningfulness of items through association with material already high in meaningfulness. A two-part learning task was employed whereby the first part paired high and low meaningful items and the second stage tested the effects of such pairings. Increases in performance on the second task, over control conditions, were an index of the extent to which the meaningfulness of the experimental material had been raised through

association. Other studies employing this same A-B, A-C learning paradigm have found significant negative transfer effects. The results of the present experiment have to be interpreted with this in mind. The findings indicated that meaningfulness can be increased by association since the expected negative transfer effects were not obtained. It was hypothesized that the amount of facilitation due to the increase in meaningfulness was sufficient to offset the predicted decrement in learning.

2. Experiment IX: Association Value, Meaningfulness, and Learning. Association values have wide acceptance as indices of meaningfulness supported by studies where performance is directly related to such scale values. The bulk of such studies, however, tested adult subjects with lists of trigrams which included a fairly wide range of association values. Experiment VII, however, while collecting scale values from children noted a tendency to respond to different restricted lists of items as if they were equivalent. That is, lists from different portions of the total range of association values yielded values that were much alike in terms of mean association value, standard deviation, and range.

The relationship between "absolute" association value and meaningfulness was examined in this study by using separate lists of CVCs, each list spanning only 10 association value points and sampling from a different interval along the total range. Seven such lists were constructed. Using the trigrams as responses, and administering each list to independent groups, it was found that relatively little change in performance level accompanied wide changes in mean association value of the lists. Although learning does covary with association values, the magnitude of this relationship is far lower than expected. This finding adds further support to the hypothesis that individual lists of items are responded to similarly. Homogeneous lists must differ vastly in mean association value before any reliable difference in performance is obtained. As the lists become more heterogeneous, differences in performance as a function of association value should be noted between items within a list. This last inference is supported by studies in the literature.

3. Experiment X: The Effects of Pronounceableness and Explicit Pronunciation on Learning. Pronounceableness has been shown to covary with performance and, on that basis, has been accepted as another parameter of the concept "meaningfulness". It has been assumed that meaningfulness serves to organize diverse stimuli into units which are more readily processed. In the same fashion, then, the facilitative effects of pronunciation are attributed to its capacity to integrate the separate letters composing the visual stimulus word into a unit with fewer elements (phonemes). The present study was designed to test the effect of pronounceableness across modalities with children and to examine whether further changes in performance result from explicit pronunciation.

To avoid confounding the results due to variations in meaningfulness, low association value trigrams were used. The CVC trigrams formed the pronounceable responses and CCC trigrams the less pronounceable items. These materials were presented either visually or auditorily, where the trigrams were spelled. An additional auditory condition for the CVC material only consisted of both spelling and pronunciation of the trigrams.

The results of this study show that the pronounceableness of items aids learning as had been anticipated. Explicit pronunciation was found to provide no further increase in learning and, in fact, interfered with learning in the sixth grade. The integration of items into pronounceable units occurred as efficiently in the auditory modality as in the visual. For low pronounceable material, the visual modality was clearly superior although discriminability of the items may be a confounding factor.

4. Experiment XI: The Effect of Similarity Upon Learning. Meaningfulness aids learning presumably by providing associative links which serve to integrate the material being presented. Acceptance of the notion of associative links is the basis for the use of association values as indices of meaningfulness. However, that such associations can also interfere with learning at times has been demonstrated empirically. Apparently, the meaningfulness of items is relative to the context in which they are embedded; items with many associations (and therefore, high in meaningfulness) can result in slower learning in some situations than in others (implying that the meaningfulness of such items is variable). In particular, interference with learning can be obtained with items which are similar in meaning, i.e., synonyms, or which are similar in being instances of a supraordinate class. For material which is low in meaning, it has been found that physical similarity, i.e., letter duplication, reduces learning.

Since children are less facile with verbal material than adults, it was decided to investigate the effects of physical and conceptual similarity upon learning to determine whether assumed differences in verbal proficiency result in different patterns of interference due to similarity. It was supposed that children, being more concrete, would be more influenced by physical rather than meaningful similarity. Since they have less experience with language, fewer associative links would be available to produce interference due to meaning. Another consequence of concreteness is that children would be less affected by items representing different instances of a higher-order concept than would adults. For children, each instance would be "concretely" unique.

The results of this experiment, comparing performance on lists which were similar physically or conceptually with control lists, indicate that children react to these variables as do adults. Letter duplication has more effect when meaning is low; conceptual similarity produces interference with meaningful material. The data suggest different strategies to learn were used at the different grades. Sixth-grade performance was more like adults implying use of an approach emphasizing verbal skills. Fourth-grade subjects were characterized as using primarily a rote approach to the task. Fifth-grade performance was not predictable from the two adjacent grades and was interpreted as the result of a transition in the learning process.

5. Experiment XII: Learning as a Function of Audio-Frequency Differences and of Cognitive Restructuring of the Task. This experiment was designed to determine whether rate of learning varies

directly with the amount of difference among stimuli. Two sets of bands of noise were selected which differed only in frequency intervals. When these stimuli were presented in the usual paired-associate paradigm, no difference in learning was obtained as a function of differences in frequency. These results suggested that the larger set of differences provided no additional information for learning than did the smaller. Apparently, once the items are sufficiently distinctive, no further increment in learning is obtained as a function of additional differentiation _along the same dimension_. This is not to say that varying the stimuli along several dimensions might not have facilitated the performance.

The level of performance with either set of stimuli in this experiment was significantly lower than had been anticipated on the basis of previous experimentation. In examining the initial random presentations of the S-R pairings, it was hypothesized that the poor performance resulted from a lack of sufficient cues for absolute identification of the stimuli necessary for recall. This hypothesis was tested by modifying the original conditions so that the stimuli were presented ordinally in terms of frequency during the learning trials. The same random presentations of stimuli during the test trials were used. These changes clearly provided anchor points for the stimuli and emphasized the relationship of each band of noise to such anchors and to each other. Performance was significantly facilitated in these modified conditions over the level demonstrated with the random presentations, being now equivalent to that obtained with other kinds of A_1 material.

The success of the modified tasks indicates the importance of providing structure in learning. Distinctive stimulation is apparently not sufficient for attainment of cognitive structure by the subjects. In order to learn, stimuli must be apprehended by the subjects and organized in such a manner that efficient recall can occur. To the extent that the subject is unable, on the basis of previous experience, to provide a suitable structure for recall, performance will be adversely affected. Thus, it is important for the instructor to provide such a framework to achieve the maximum amount of learning in a given time. These findings have great implications for auditory training of hearing-handicapped children.

6. Experiment XIII: Meaning and a Context of Utility. In this final experiment of the project, an attempt was made to evaluate the effect upon performance of adding cognitive structure when verbal material was used. As already noted, dramatic increases in performance were obtained when structure was provided for auditory nonmeaningful-nonverbal material which differed along a single dimension. In this experiment, the stimuli were trigrams which can be termed complex stimuli varying along many dimensions. In obtaining association values for such material, the items are ranked along the single dimension "meaningfulness"; however, it must be remembered that they differ in spelling and pronounceableness, to mention only two more obvious parameters.

Cognitive structure was loosely defined as that which increases the meaningfulness of the material, since meaningfulness is measured by performance. With verbal material, meaningfulness cannot logically be increased by establishing reference points as was used with the nonverbal material. However, this type of material is amenable to communication functions. Therefore, it was hypothesized that performance would be facilitated by implying that a meaningful relationship exists between the S-R pairs; i.e., that the trigram would be equally communicable under certain circumstances as would the item with which it is paired. This hypothesis was tested by pairing trigrams with Arabic numbers and informing the subjects that the trigrams were the names for those numbers in a particular foreign language.

Three lists from Experiment IX were used for this study, representing low, medium, and high mean association values. Performance from that study was used as the control for this experiment to adequately measure the effect of changes in instruction upon performance.

The results of this experiment do not allow any clear-cut statement to be made concerning the effect of providing structure upon meaningfulness. An interaction with association value was obtained; only the list of medium-valued trigrams was facilitated by the implication of meaning in the S-R pairings. A significant interaction between grades and instructions was also obtained in which the sixth-grade performance was adversely affected by the changed instructions while the other grades reacted in the opposite direction. In addition, the grades responded differently to the three levels of association value used, yielding another significant interaction. These results were discussed in terms of the assumed changes in language development represented by these grade levels.

7. Conclusions. The studies conducted in connection with meaningfulness indicate that this concept is more complex than had been assumed from previous experimentation with adult subjects. Using the operational definition of performance as an index of meaningfulness, it was shown that parameters such as pronounceableness and discriminability affect learning in children in the same manner as they do in adults. However, meaningfulness is not to be viewed in an absolute fashion but is relative to the context in which the material to be learned is placed. The finding that lists of narrow ranges of absolute association values are learned almost as rapidly regardless of the absolute mean value is inconsistent with previous notions and lends support to the concept of relative meaningfulness. Additional evidence for this view is found in the effects of similarity upon performance and in the changes in learning as a result of changing the structure of the task. To the extent that the same materials produce different levels of performance in these different situations, meaning can be said to be relative.

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APPENDICES

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Appendix B. Directions for Collection of Association Values... 242

Appendix C. Copies of Answer Sheets Used to Obtain Association Values.. 244

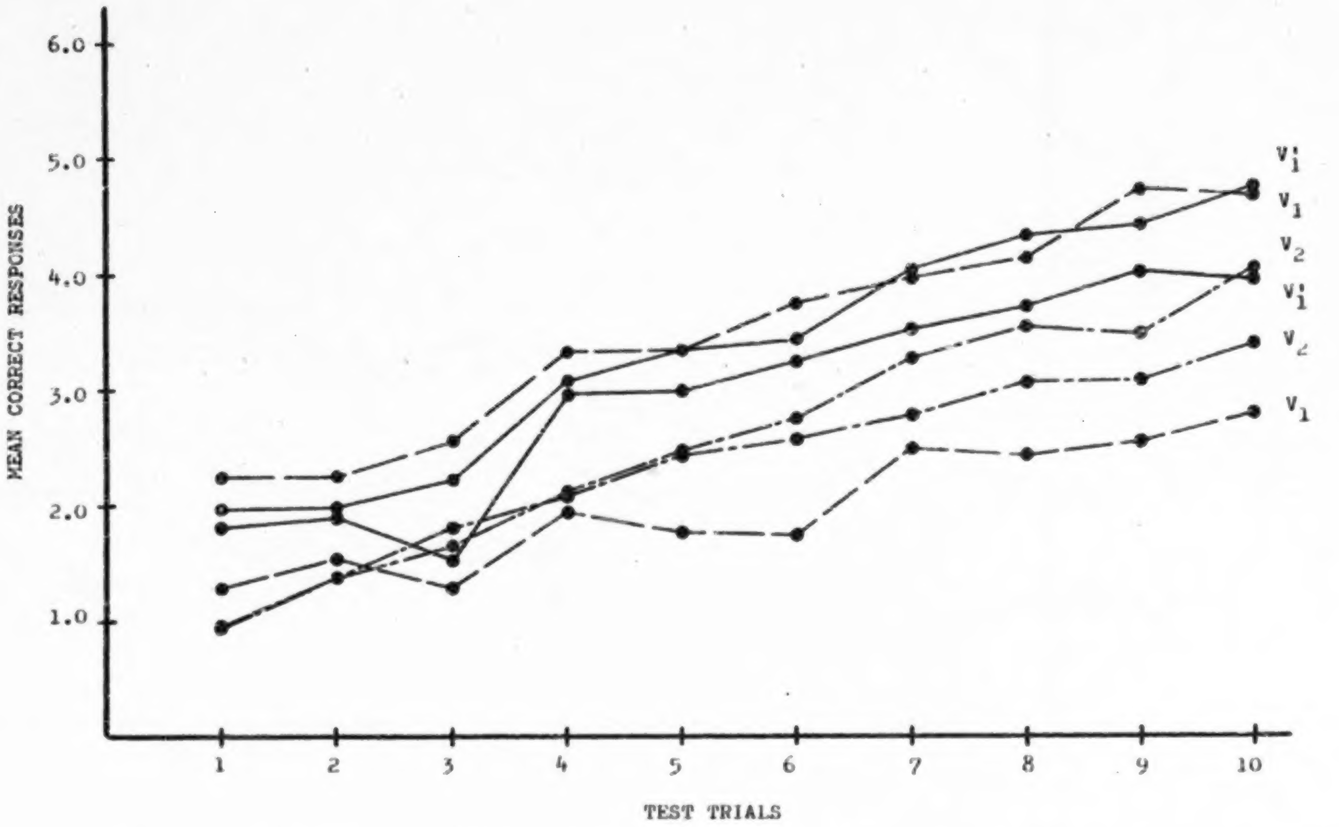

Fig. A-1 Experiment I: Learning curves for Conditions V_1', V_1, and V_2; grades 4 (closed circles) and 5 (open circles).

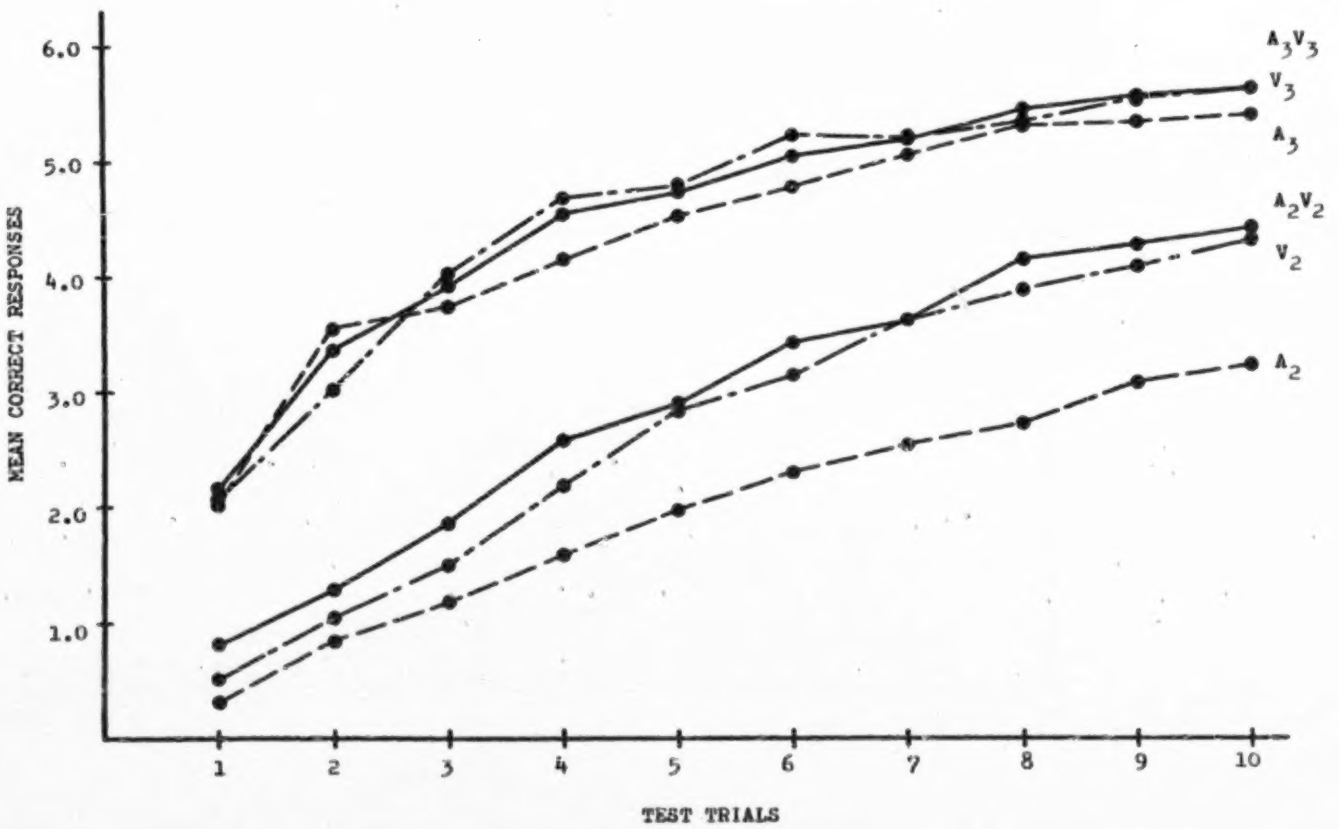

Fig. A-2 Experiment II: Learning curves for Conditions A_2, A_3, V_2, V_3, A_2V_2, and A_3V_3; grade 6.

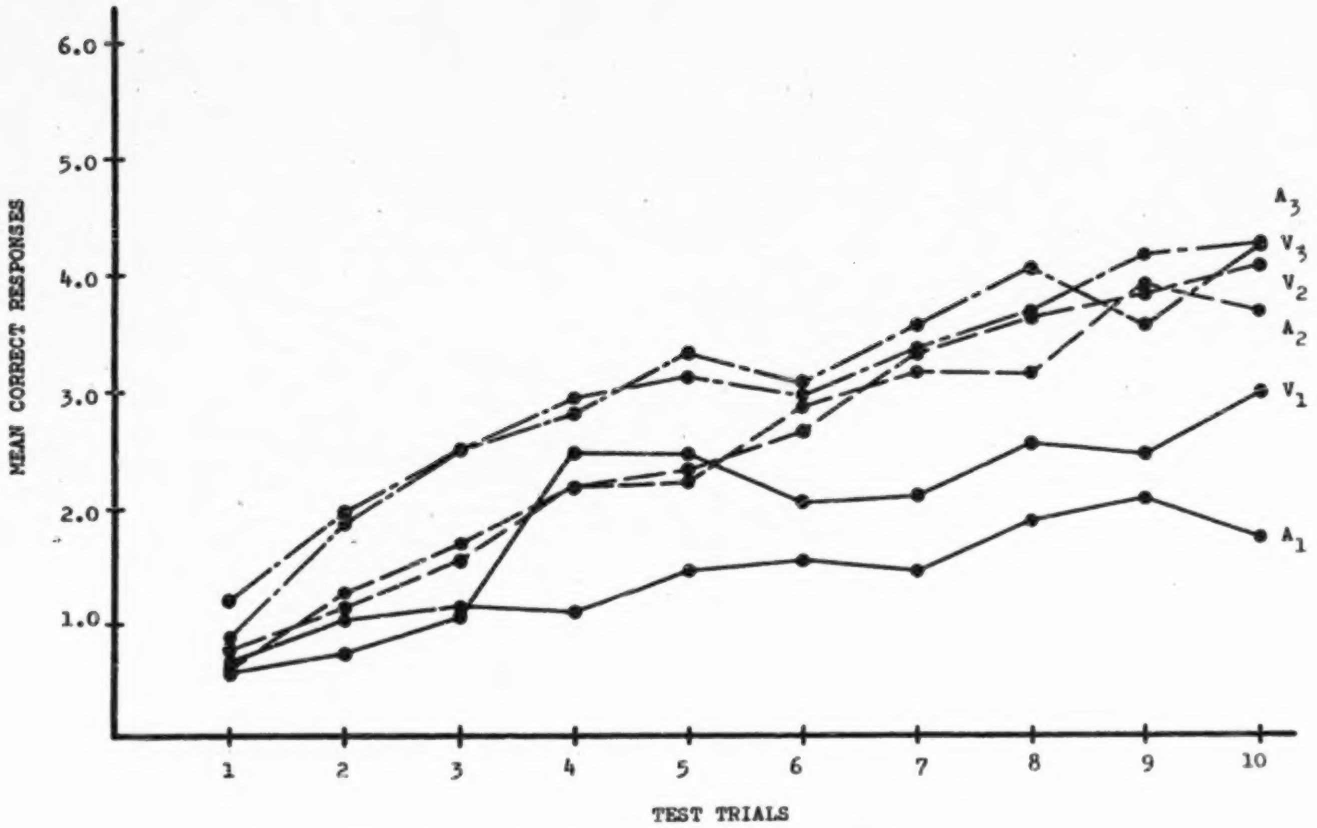

Fig. A-3 Experiment III-2: Learning curves for unimodal testing of Conditions A_1V_1, A_2V_2, and A_3V_3; grade 4.

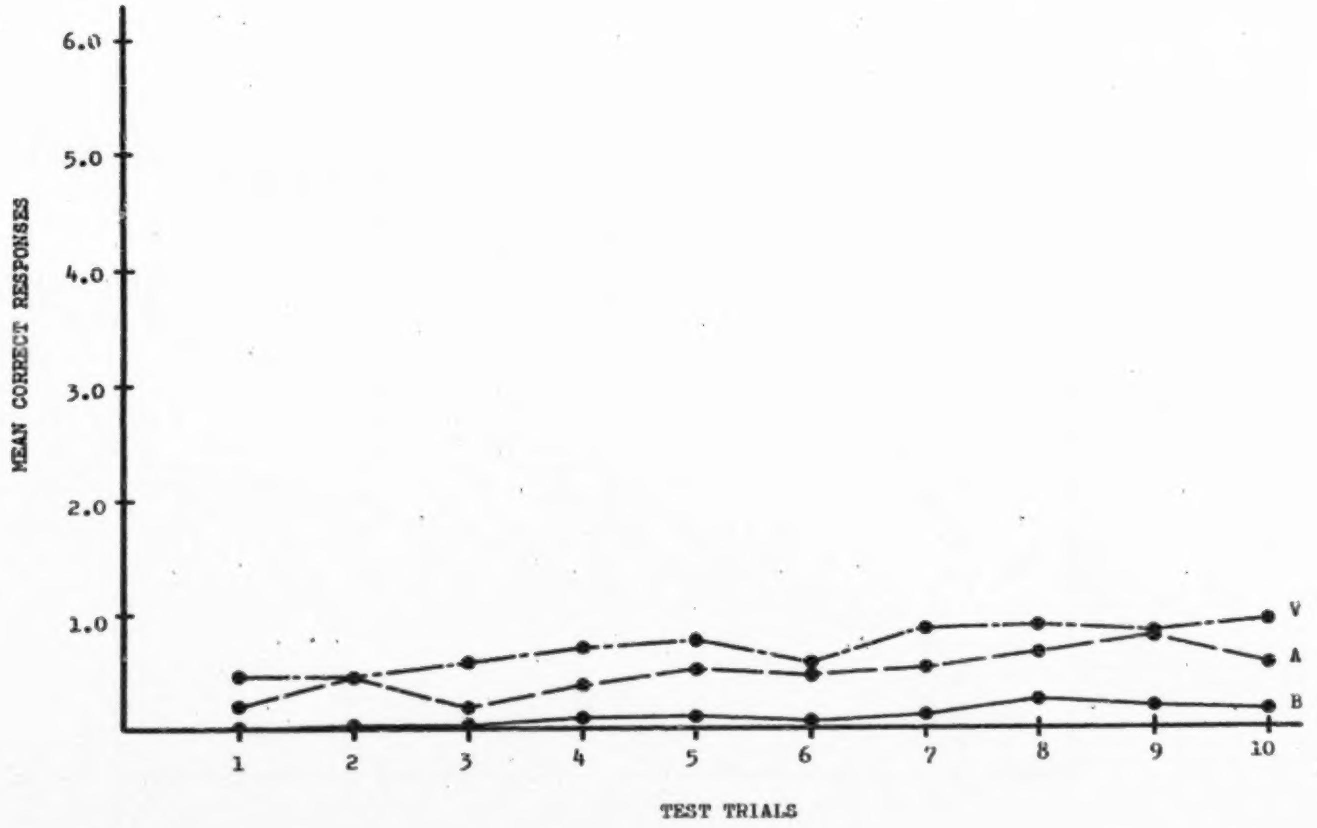

Fig. A-4 Experiment III-3: Learning curves for material in each modality and for bimodal performance; grade 4.

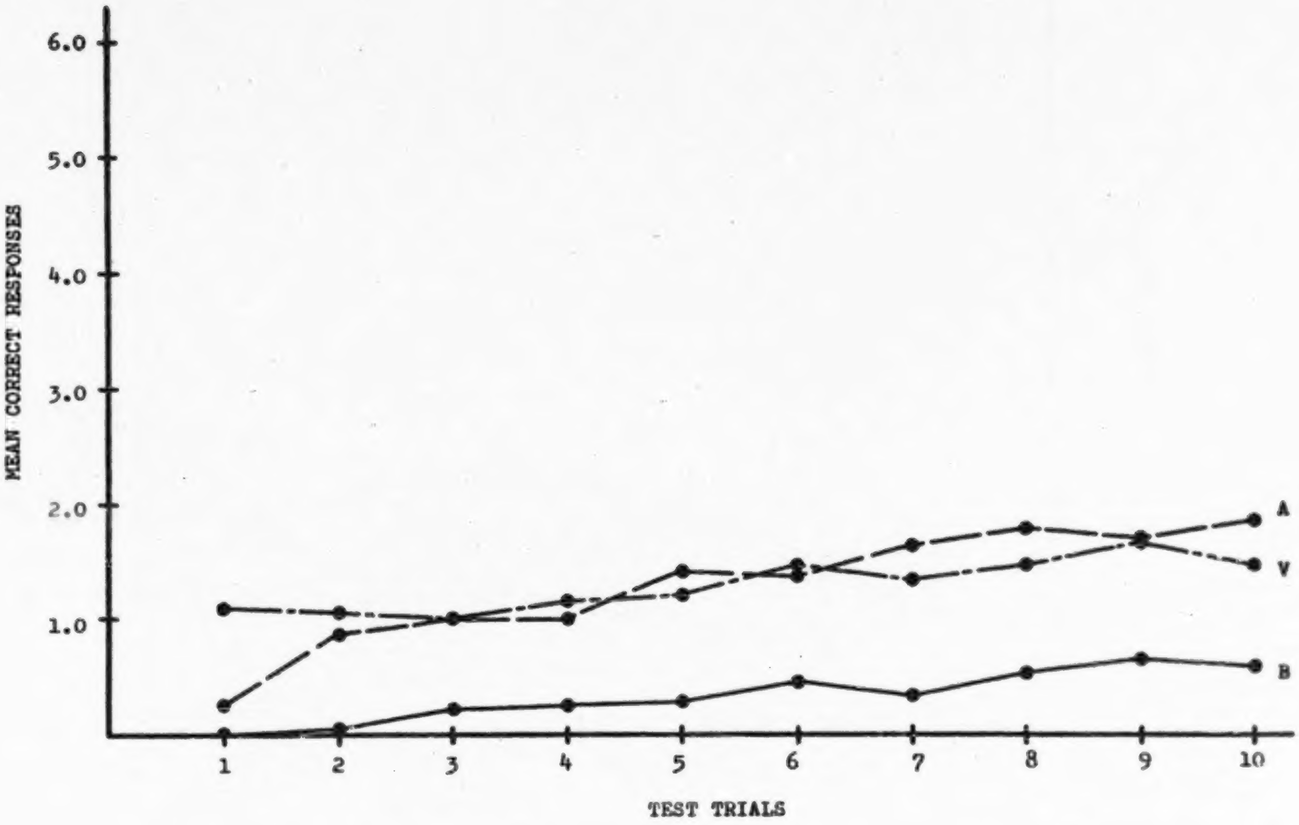

Fig. A-5 Experiment III-3: Learning curves for material in each modality and for bimodal performance; grade 5.

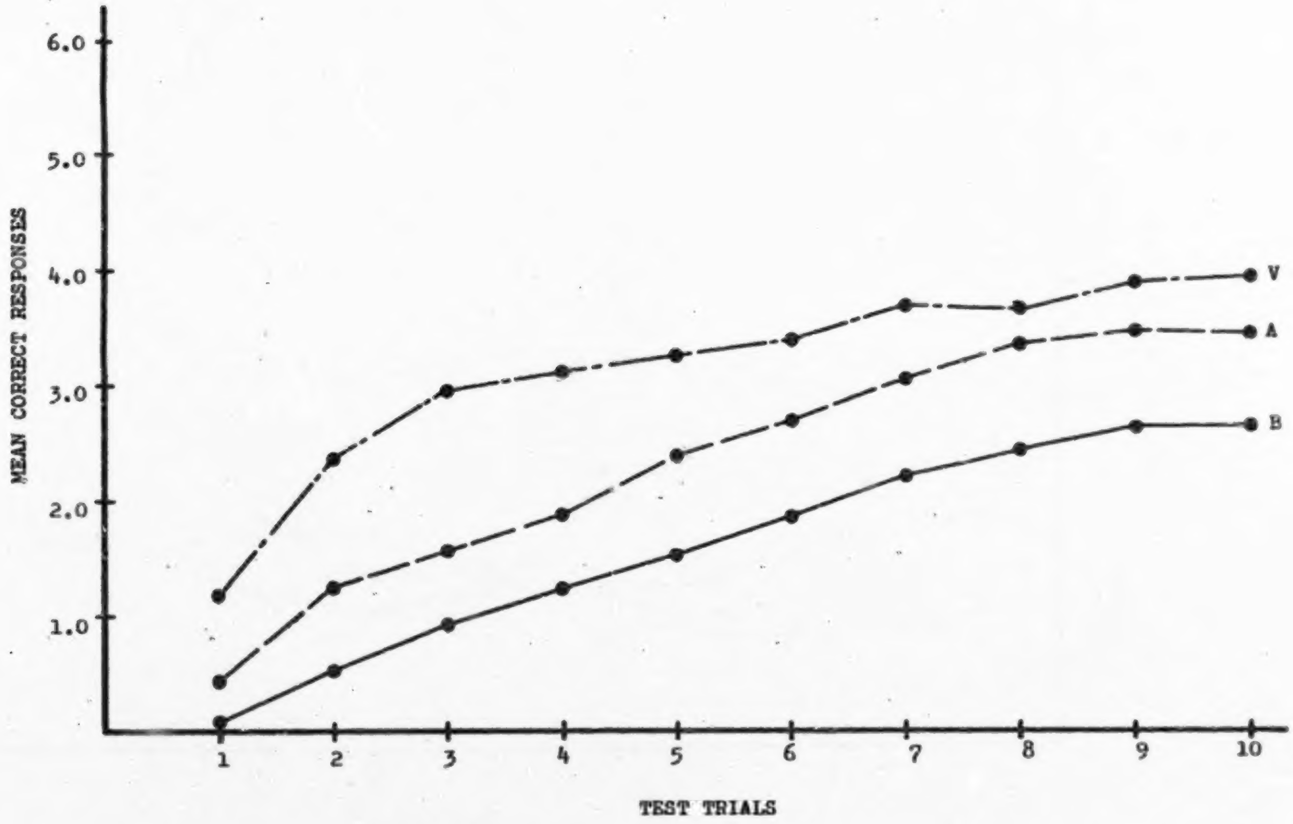

Fig. A-6 Experiment III-3: Learning curves for material in each modality and for bimodal performance; grade 6.

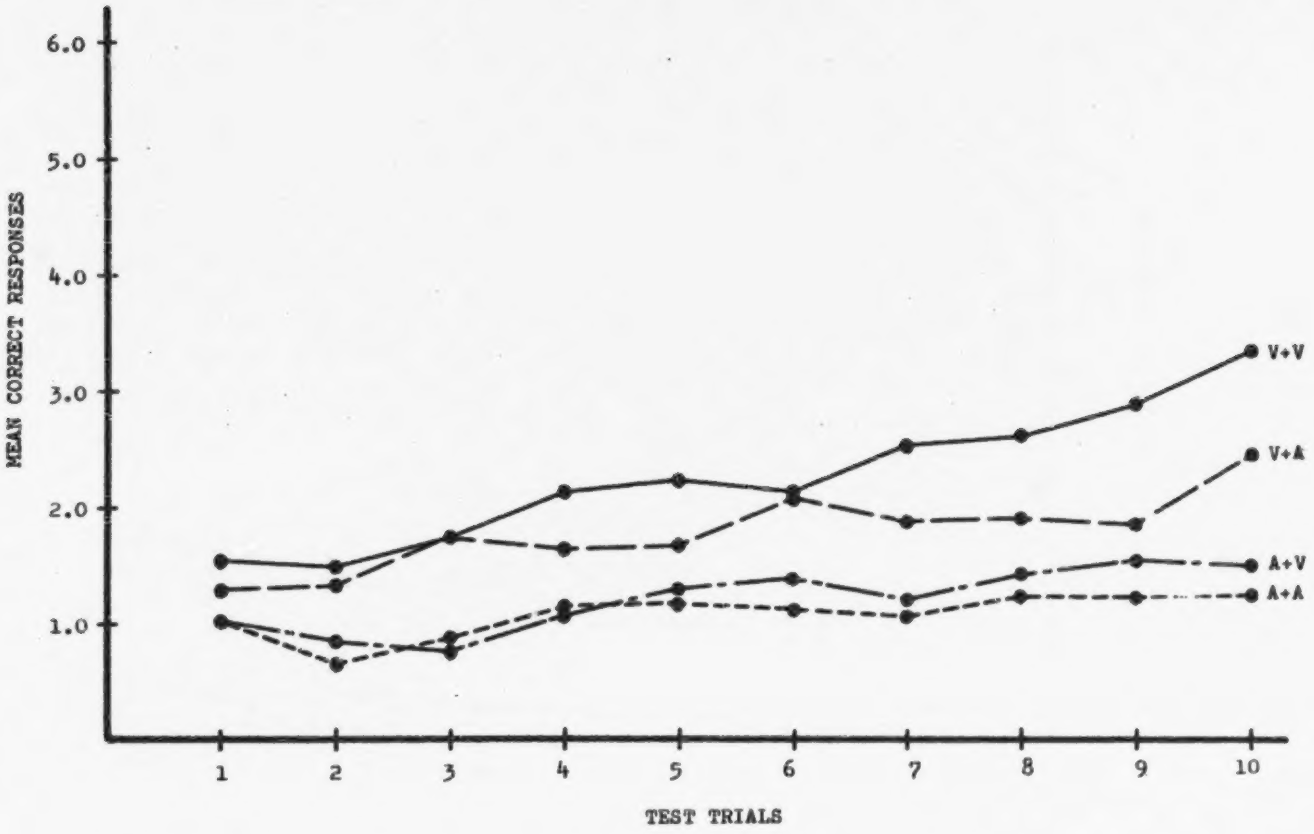

Fig. A-7 Experiment V: Learning curves for Conditions V+V, V+A, A+V, and A+A; grade 4.

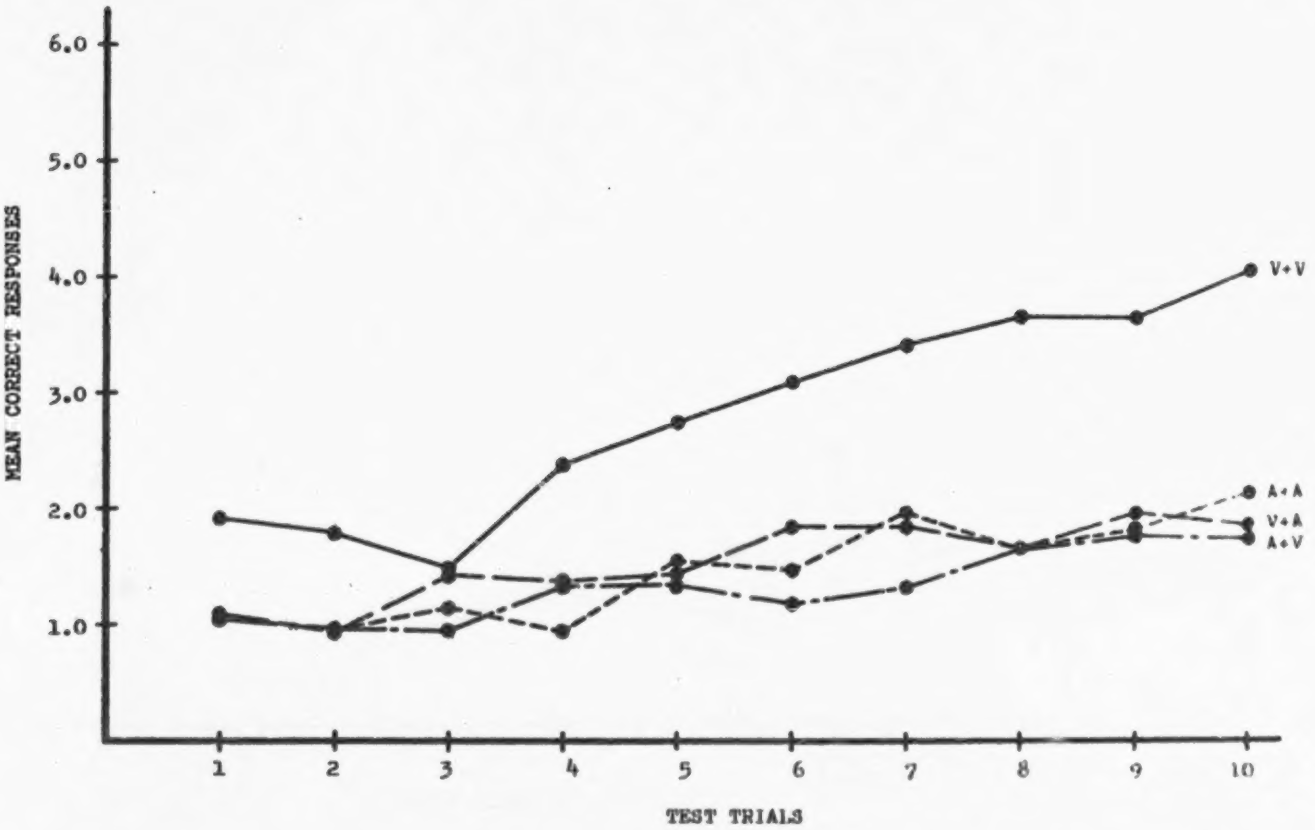

Fig. A-8 Experiment V: Learning curves for Conditions V+V, V+A, A+V, and A+A; grade 6.

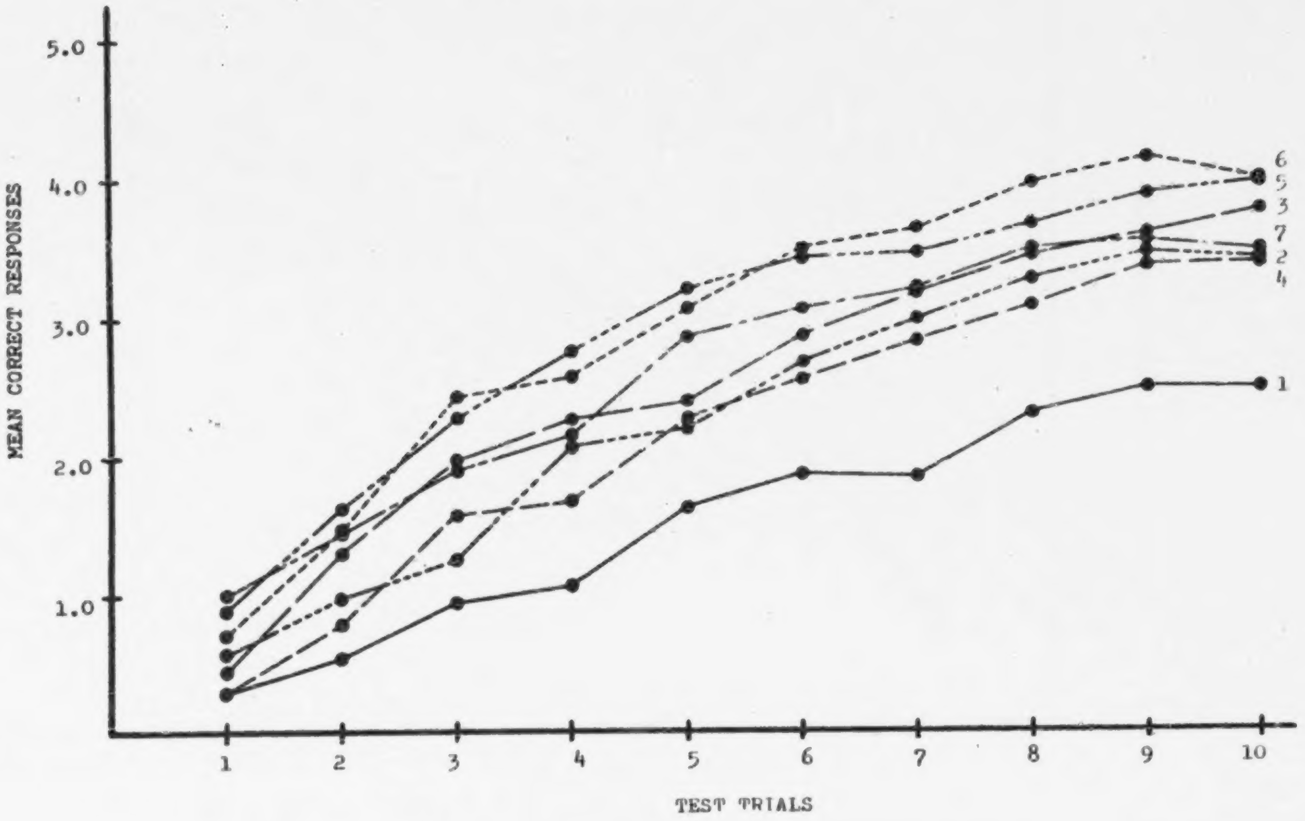

Fig. A-9 Experiment IX: Learning curves for seven conditions; grade 4.

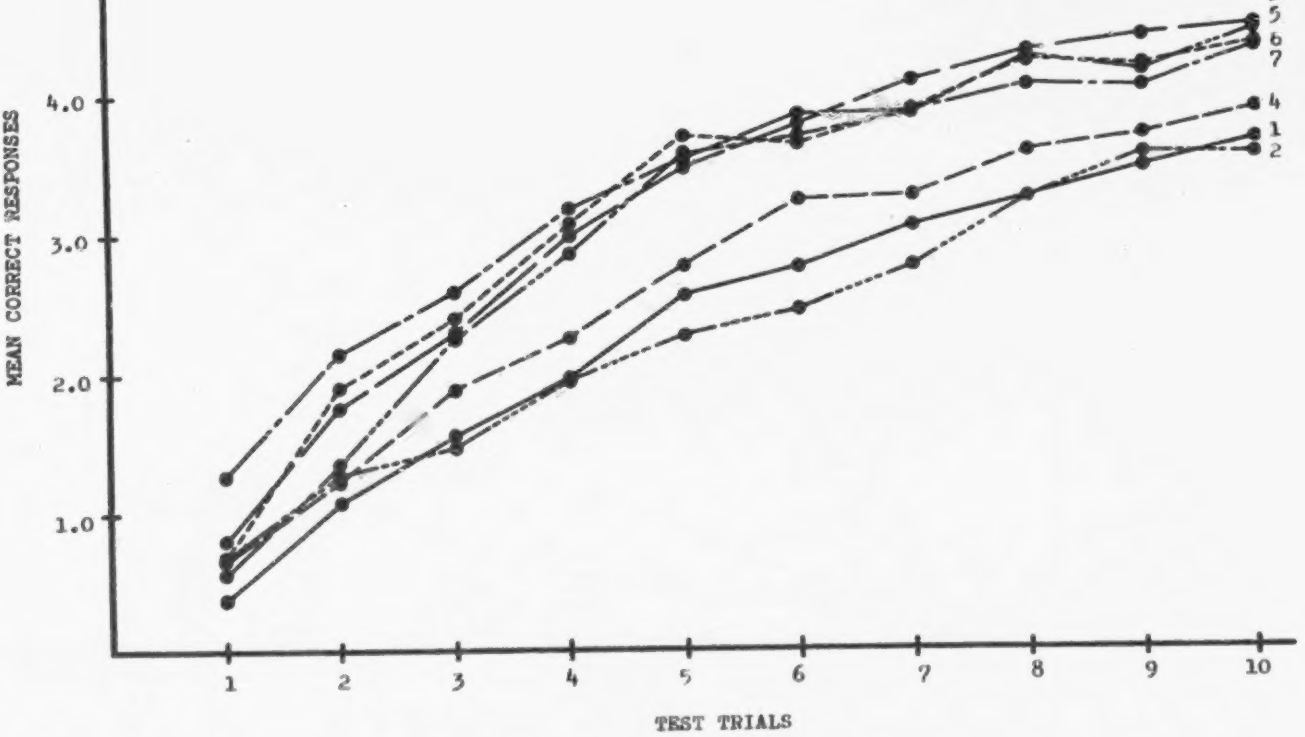

Fig. A-10 Experiment IX: Learning curves for seven conditions; grade 5.

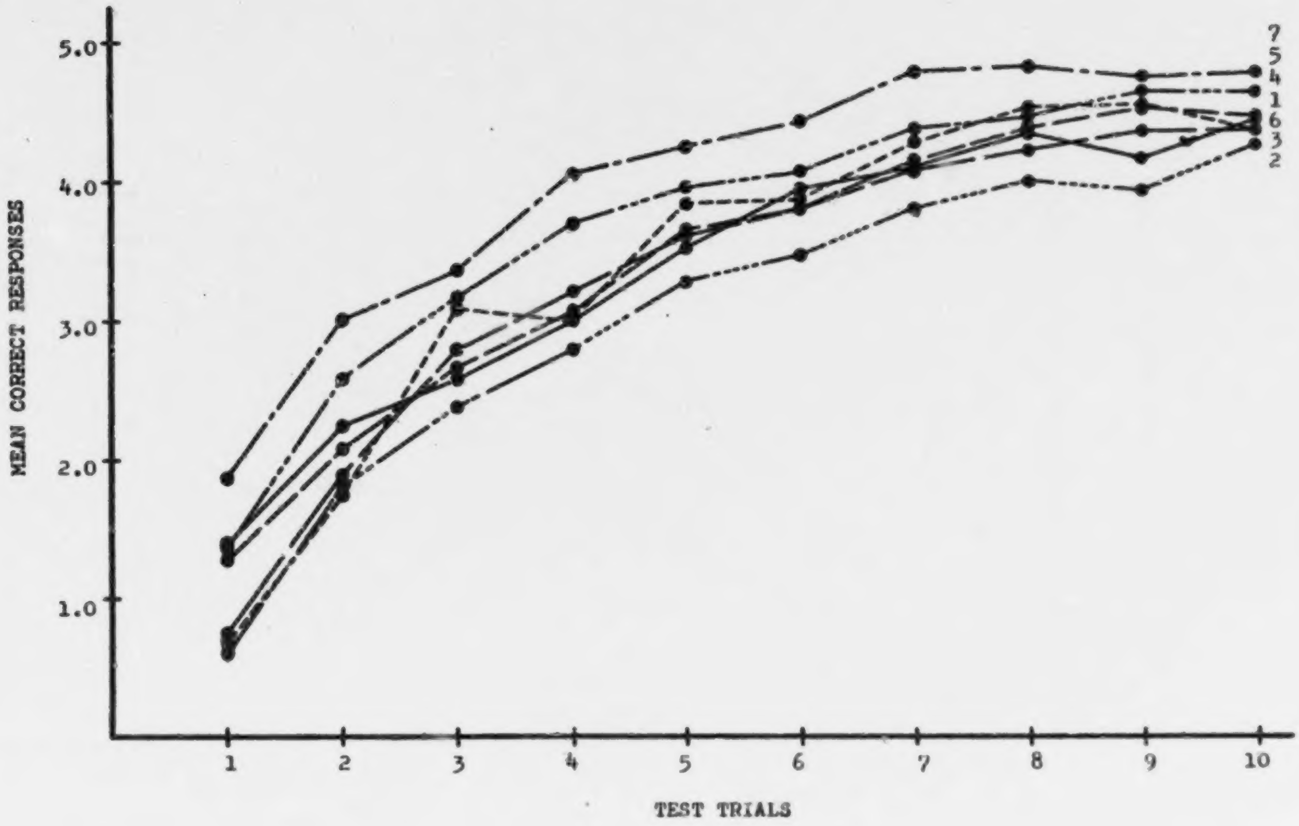

Fig. A-11 Experiment IX: Learning curves for seven conditions; grade 6.

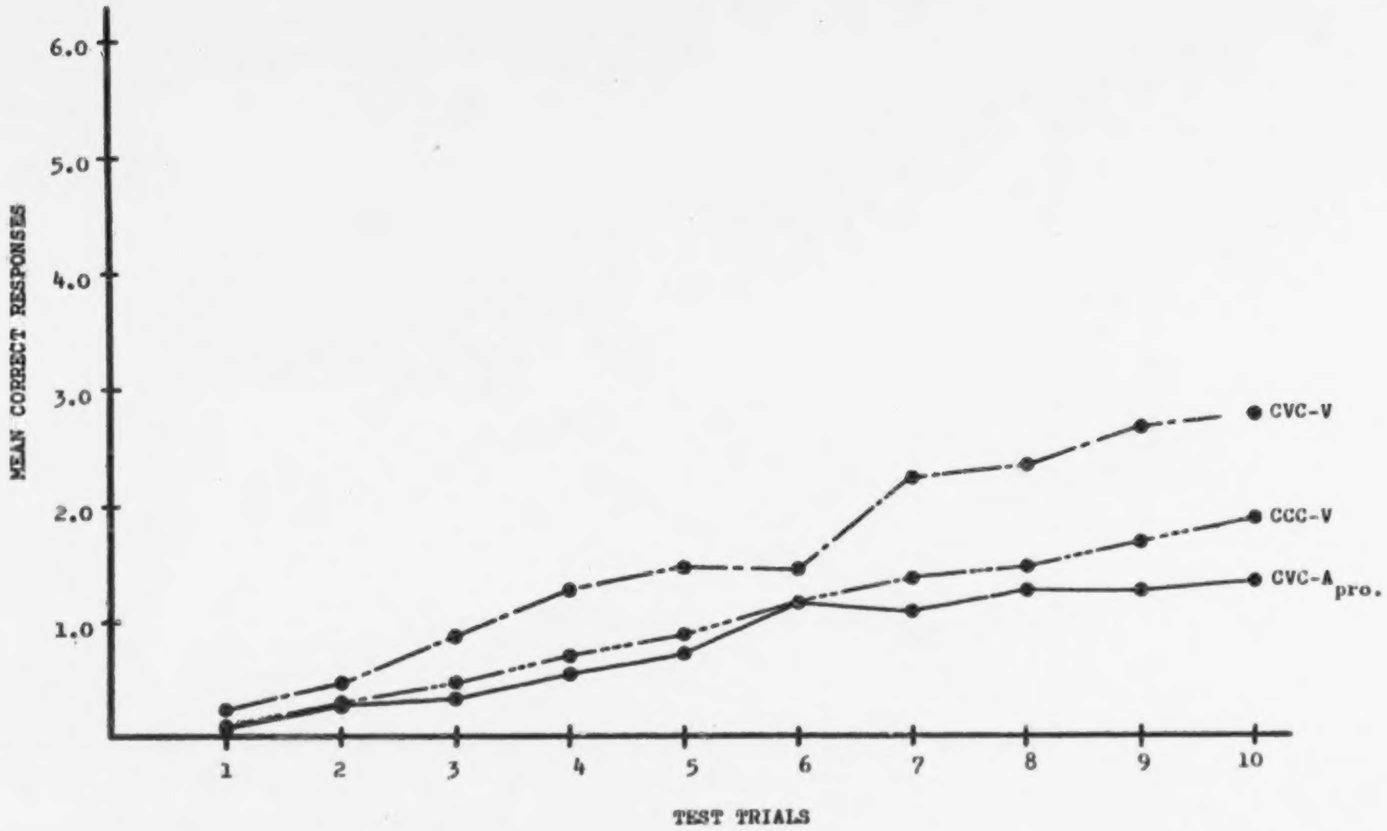

Fig. A-12 Experiment X: Learning curves for Conditions CVC-V, CCC-V, and CVC-$A_{pro.}$; grade 4.

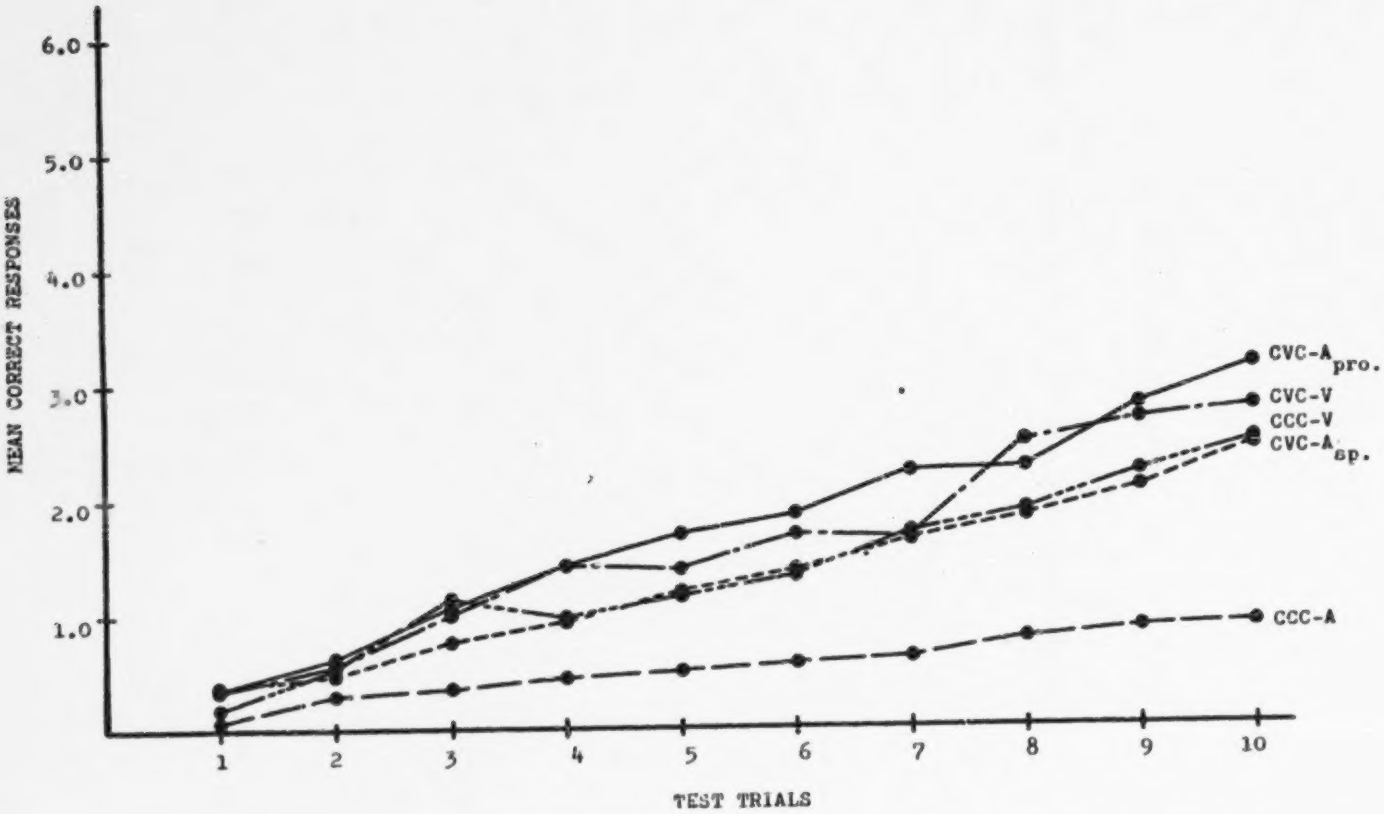

Fig. A-13 Experiment X: Learning curves for Conditions CVC-V, CCC-V, CVC-$A_{sp.}$, CCC-A, and CVC-$A_{pro.}$; grade 5.

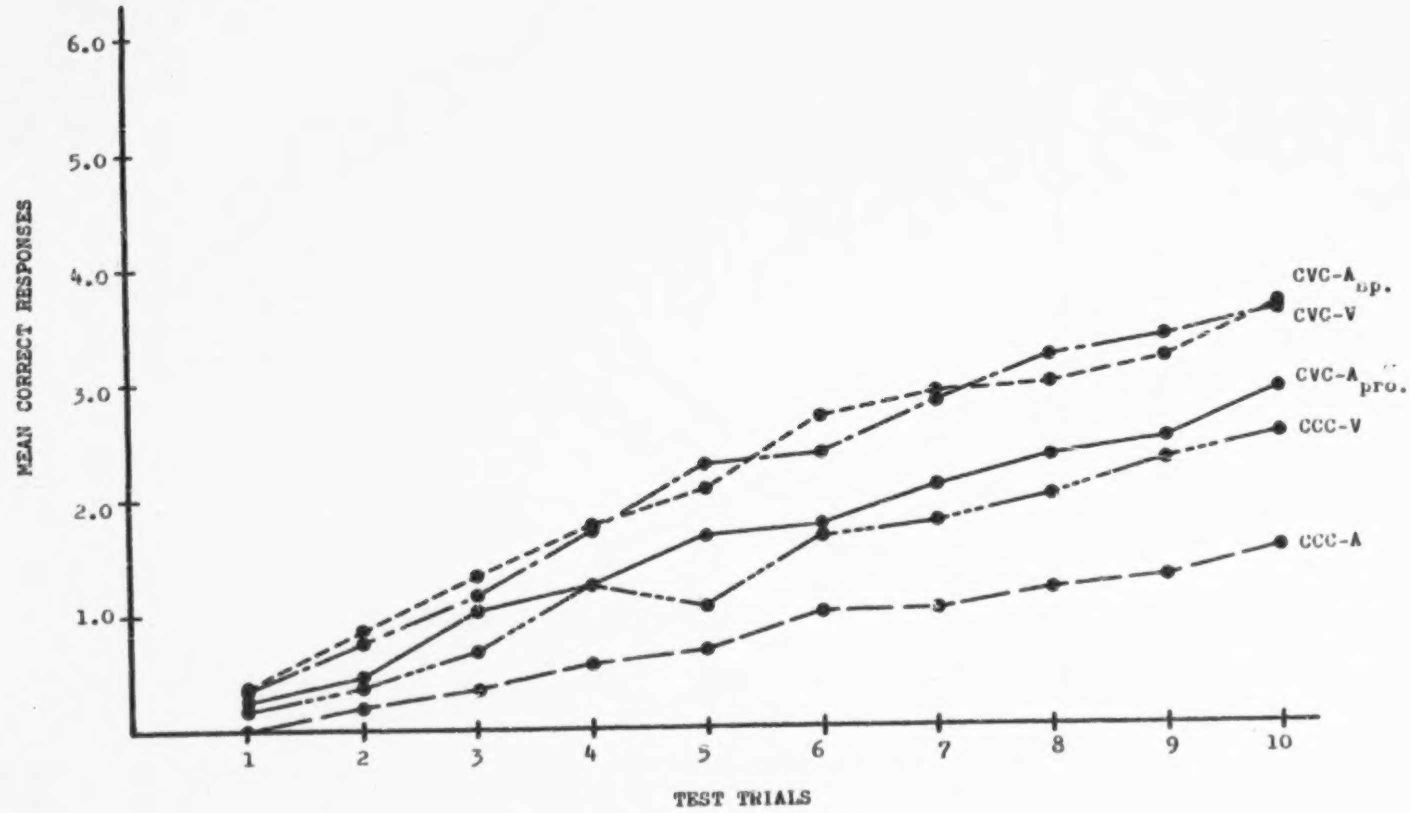

Fig. A-14 Experiment X: Learning curves for Conditions CVC-V, CCC-V, CVC-$A_{sp.}$, CCC-A, and CVC-$A_{pro.}$; grade 6.

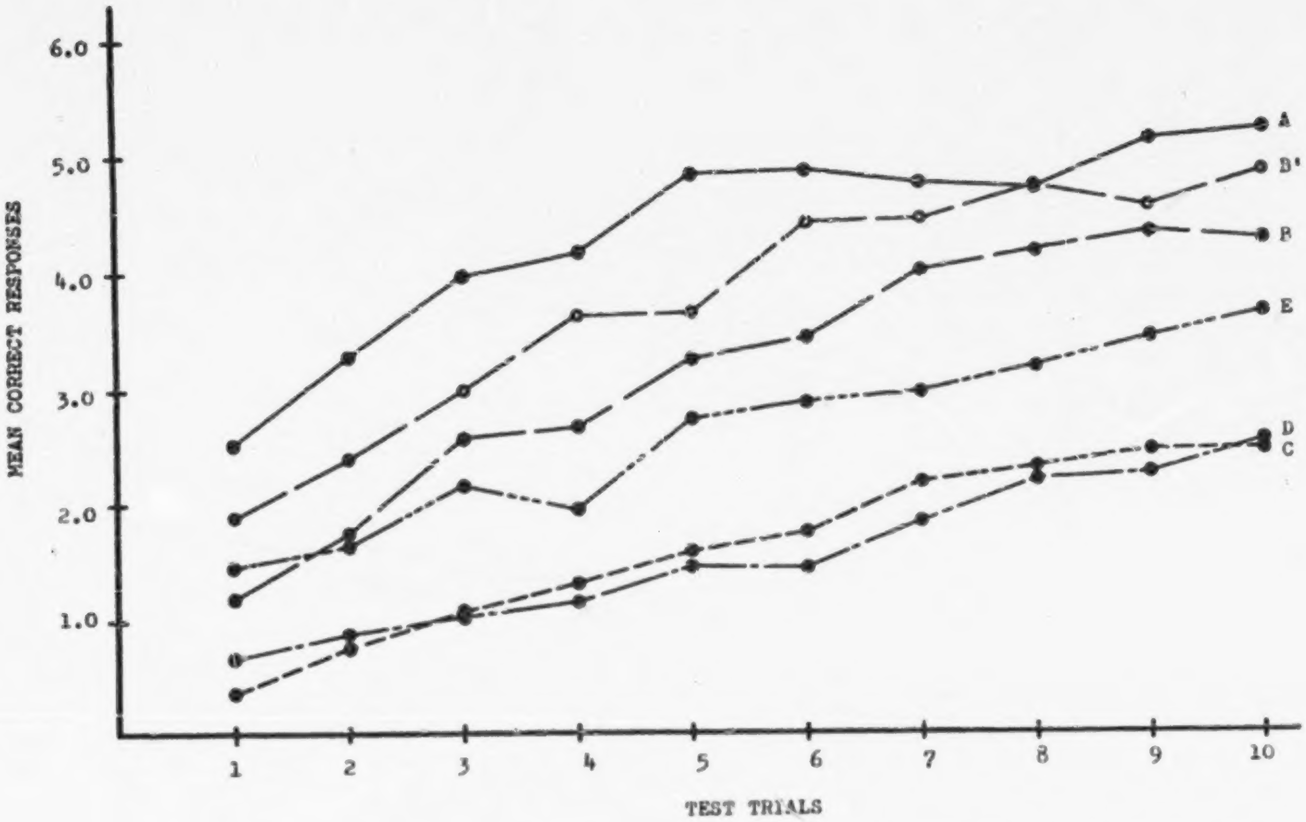

Fig. A-15 Experiment XI: Learning curves for Conditions A, B, B', C, D, and E; grade 4.

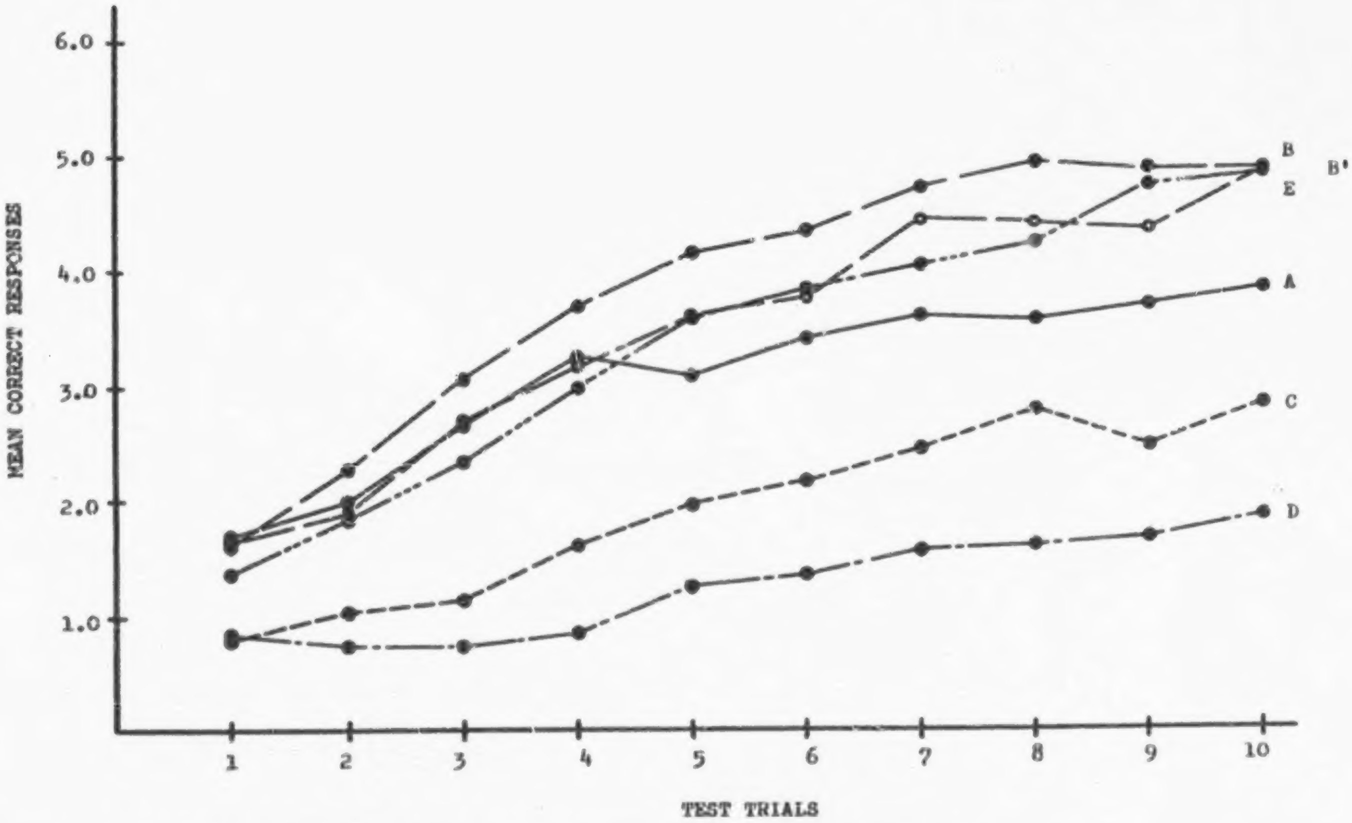

Fig. A-16 Experiment XI: Learning curves for Conditions A, B, B', C, D, and E; grade 5.

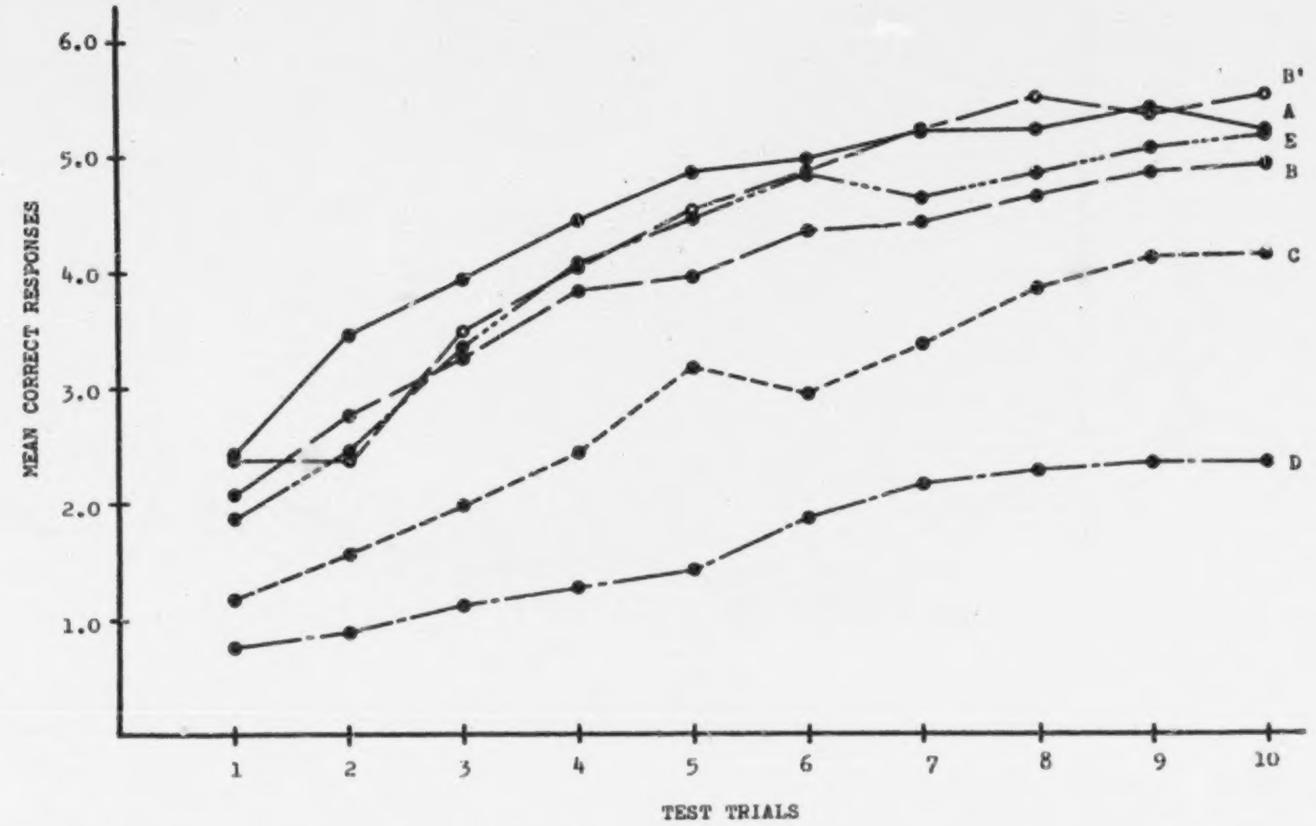

Fig. A-17 Experiment XI: Learning curves for Conditions A, B, B', *C*, *D*, *and E*; *grade 6*.

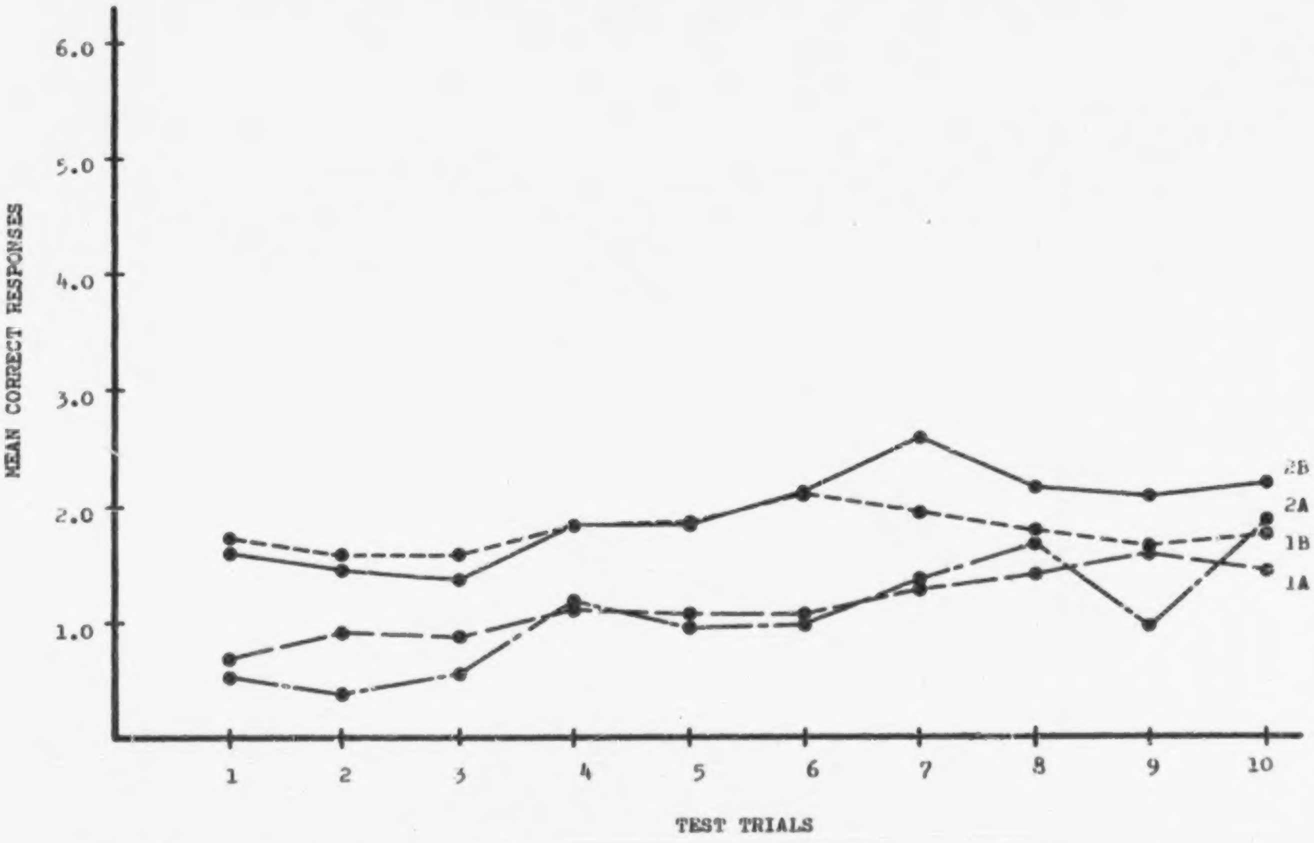

Fig. A-18 Experiment XII: Learning curves for Conditions 1A, 2A, 1B, and 2B; grade 4.

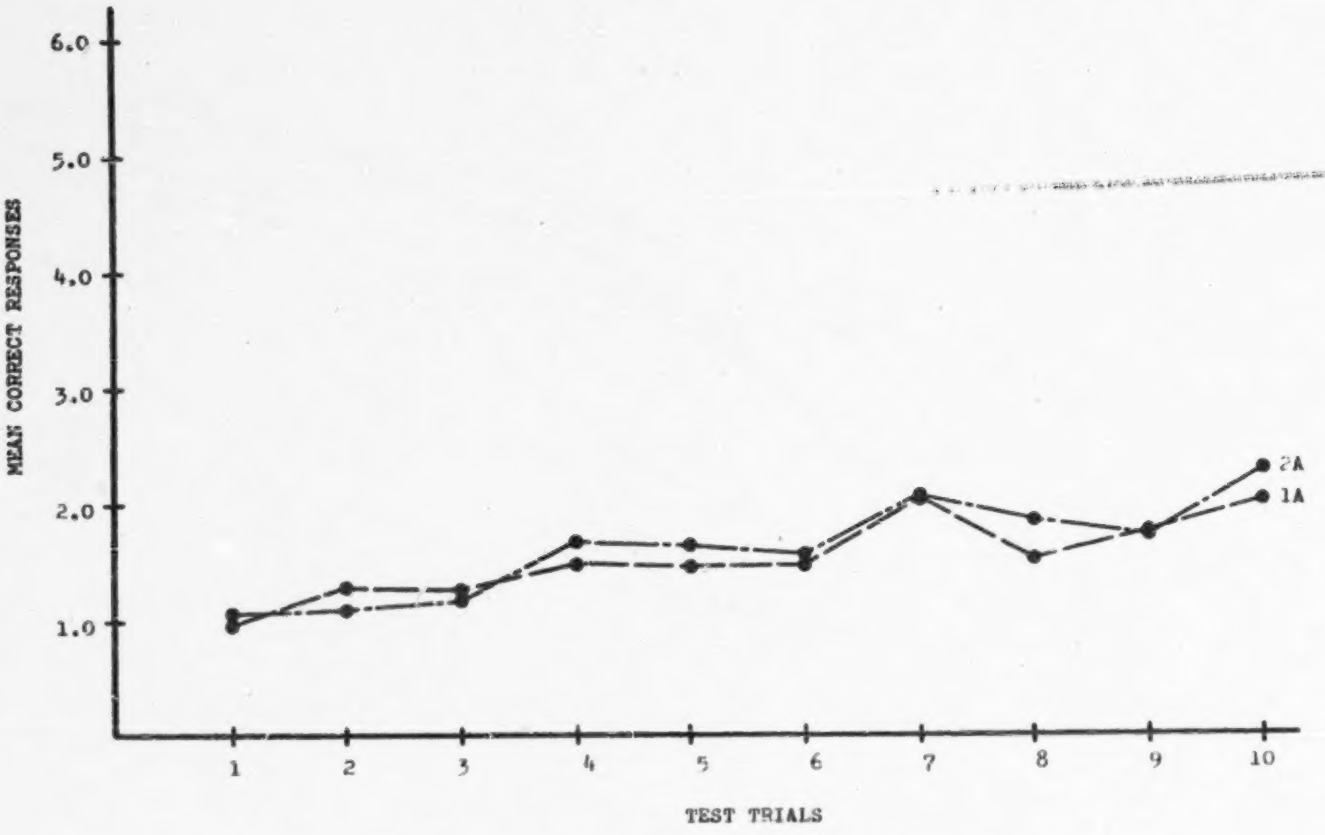

Fig. A-19 Experiment XII: Learning curves for Conditions 1A and 2A; grade 6.

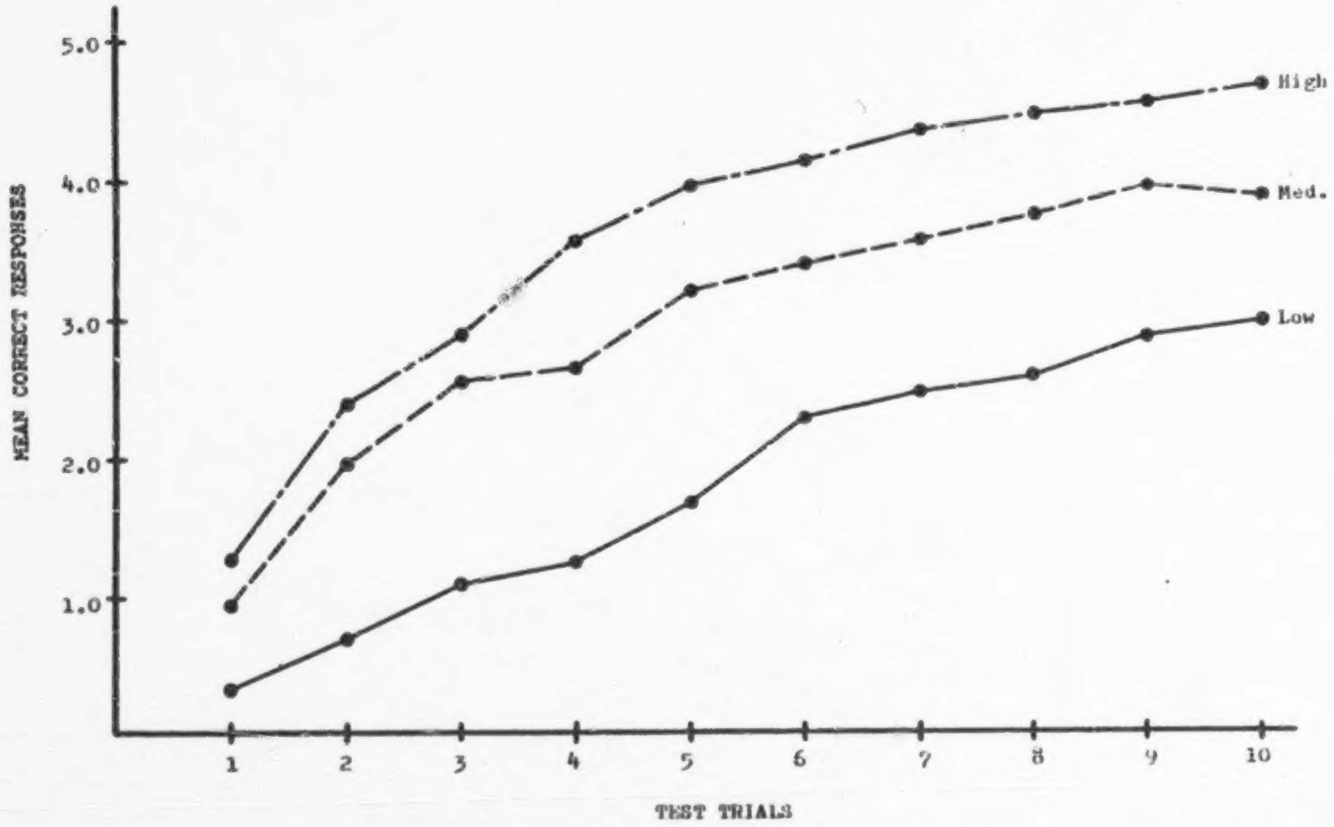

Fig. A-20 Experiment XIII: Learning curves for three experimental conditions; grade 4.

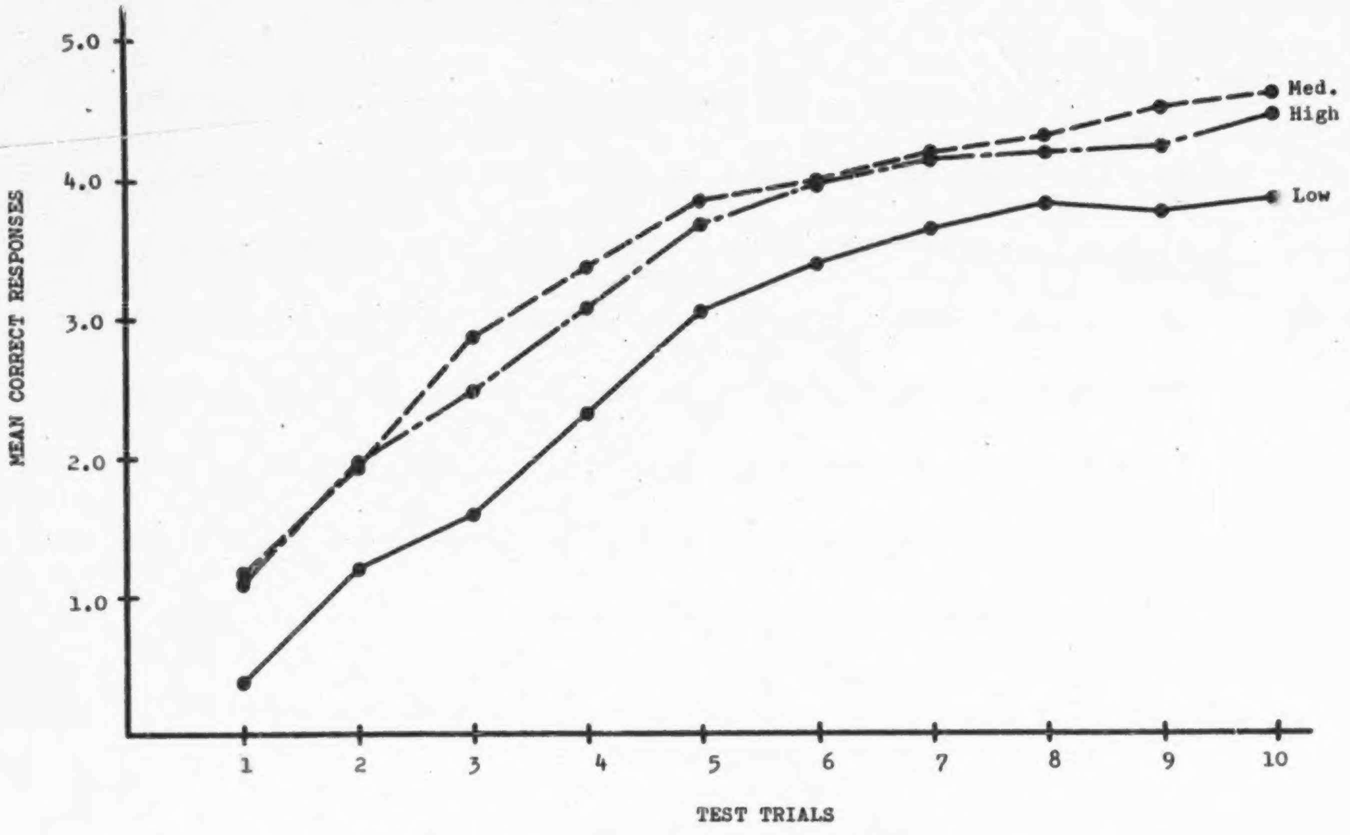

Fig. A-21 Experiment XIII: Learning curves for three experimental conditions; grade 5.

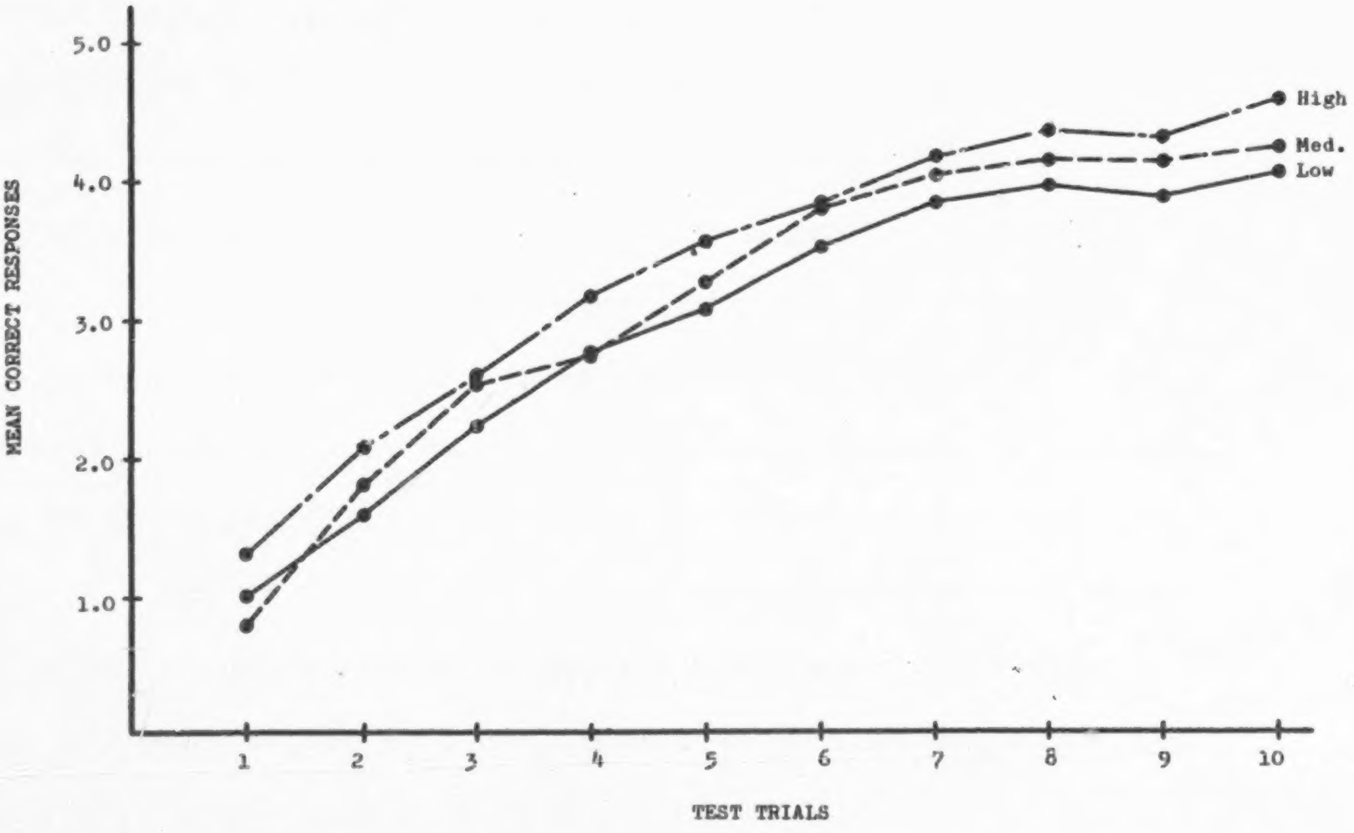

Fig. A-22 Experiment XIII: Learning curves for three experimental conditions; grade 6.

DIRECTIONS FOR COLLECTION OF ASSOCIATION VALUES

On the page(s) we gave you, there are sets of letters followed by "Yes" and "No". What we want you to do is to tell us if these sets of letters are like words. We have given these lists to grown-ups, (college students and people like your parents) and they have told us that some of these sets of letters are more like words than others. We want to know if you feel the same way about them.

Look at each one of the sets of letters separately and ask yourself the following questions:

Is it a word?

Does it seem like a word?

Does it remind me of a word?

Can I use it in a sentence?

If you feel that you could answer any one of these questions "Yes", then place a checkmark or an X after "Yes" following those letters. If you feel that all the questions should be answered "No", then put the checkmark or X after the "No" following those letters. Do this with each set of letters. Don't skip any.

This isn't a test of any kind. There are no right or wrong answers to these sets of letters. A particular set of letters may seem like a word to you but not to your neighbor, so don't worry about what his answers are.

One thing more: Don't think to yourself "These are all letters and words are made up of letters, so I'll answer them all 'yes'," or

"None of these are actually words so I'll answer them all 'no'." This isn't what we want. Just look at each set of letters separately and try to decide if it seems like a word. Don't skip any of them. Answer every one. There is no time limit but this shouldn't take you too long. If you can't read some of the letters, raise your hand and we'll tell you what they are.

(Start them to work. If they ask questions like "Can I read it backwards?", just repeat "If it reminds you of a word, answer it 'yes'.")

CVC-50
Order 1

YAT Yes ___ No ___

KEZ Yes ___ No ___

NAB Yes ___ No ___

XYH Yes ___ No ___

HEJ Yes ___ No ___

KIH Yes ___ No ___

XEG Yes ___ No ___

HIK Yes ___ No ___

QAZ Yes ___ No ___

RUN Yes ___ No ___

REB Yes ___ No ___

PYM Yes ___ No ___

SAF Yes ___ No ___

JID Yes ___ No ___

PAG Yes ___ No ___

QAM Yes ___ No ___

ZEG Yes ___ No ___

VYS Yes ___ No ___

TAZ Yes ___ No ___

KYT Yes ___ No ___

TER Yes ___ No ___

WUB Yes ___ No ___

BIF Yes ___ No ___

HUK Yes ___ No ___

YUM Yes ___ No ___

ZUP Yes ___ No ___

WAM Yes ___ No ___

GAN Yes ___ No ___

KUL Yes ___ No ___

BYG Yes ___ No ___

BEJ Yes ___ No ___

COF Yes ___ No ___

FIP Yes ___ No ___

LUN Yes ___ No ___

LAV Yes ___ No ___

NYJ Yes ___ No ___

WOJ Yes ___ No ___

PIL Yes ___ No ___

CYL Yes ___ No ___

XIM Yes ___ No ___

HEX Yes ___ No ___

NEZ Yes ___ No ___

LYG Yes ___ No ___

DYL Yes ___ No ___

DOR Yes ___ No ___

TUS Yes ___ No ___

DAQ Yes ___ No ___

FYT Yes ___ No ___

QOJ Yes ___ No ___

MOV Yes ___ No ___

CVC-50
Order 2

BIF Yes ___ No ___

BEJ Yes ___ No ___

QAM Yes ___ No ___

NEZ Yes ___ No ___

ZUP Yes ___ No ___

NYJ Yes ___ No ___

PIL Yes ___ No ___

PYM Yes ___ No ___

FYT Yes ___ No ___

BYG Yes ___ No ___

REB Yes ___ No ___

HIK Yes ___ No ___

WUB Yes ___ No ___

HEJ Yes ___ No ___

WOJ Yes ___ No ___

HUK Yes ___ No ___

LUN Yes ___ No ___

TUS Yes ___ No ___

XYH Yes ___ No ___

XEG Yes ___ No ___

YUM Yes ___ No ___

QAZ Yes ___ No ___

COF Yes ___ No ___

NAB Yes ___ No ___

LAV Yes ___ No ___

PAG Yes ___ No ___

LYG Yes ___ No ___

DOR Yes ___ No ___

TAZ Yes ___ No ___

VYS Yes ___ No ___

QOJ Yes ___ No ___

CYL Yes ___ No ___

HEX Yes ___ No ___

RUN Yes ___ No ___

GAN Yes ___ No ___

MOV Yes ___ No ___

KYT Yes ___ No ___

XIM Yes ___ No ___

KIH Yes ___ No ___

DAQ Yes ___ No ___

SAF Yes ___ No ___

DYL Yes ___ No ___

YAT Yes ___ No ___

WAM Yes ___ No ___

TER Yes ___ No ___

KEZ Yes ___ No ___

ZEG Yes ___ No ___

KUL Yes ___ No ___

FIP Yes ___ No ___

JID Yes ___ No ___

CVC-50
Order 3

QAM Yes ___ No ___
PYM Yes ___ No ___
YAT Yes ___ No ___
LUN Yes ___ No ___
CYL Yes ___ No ___
QOJ Yes ___ No ___
ZEG Yes ___ No ___
HIK Yes ___ No ___
NYJ Yes ___ No ___
JID Yes ___ No ___
KYT Yes ___ No ___
XYH Yes ___ No ___
HEJ Yes ___ No ___
KUL Yes ___ No ___
WUB Yes ___ No ___
XIM Yes ___ No ___
RUN Yes ___ No ___
HEX Yes ___ No ___
TER Yes ___ No ___
TUS Yes ___ No ___
COF Yes ___ No ___
BYG Yes ___ No ___
VYS Yes ___ No ___
XEG Yes ___ No ___
YUM Yes ___ No ___

PAG Yes ___ No ___
REB Yes ___ No ___
HUK Yes ___ No ___
FIP Yes ___ No ___
BIF Yes ___ No ___
MOV Yes ___ No ___
NEZ Yes ___ No ___
FYT Yes ___ No ___
PIL Yes ___ No ___
GAN Yes ___ No ___
ZUP Yes ___ No ___
BEJ Yes ___ No ___
QAZ Yes ___ No ___
DOR Yes ___ No ___
DYL Yes ___ No ___
DAQ Yes ___ No ___
TAZ Yes ___ No ___
WOJ Yes ___ No ___
NAB Yes ___ No ___
LAV Yes ___ No ___
KEZ Yes ___ No ___
KIH Yes ___ No ___
WAM Yes ___ No ___
SAF Yes ___ No ___
LYG Yes ___ No ___

CVC-100
Order 1

KUL Yes ___ No ___
DYJ Yes ___ No ___
SYB Yes ___ No ___
HYN Yes ___ No ___
KEZ Yes ___ No ___
PES Yes ___ No ___
QYH Yes ___ No ___
JID Yes ___ No ___
QOJ Yes ___ No ___
NAB Yes ___ No ___
CUX Yes ___ No ___
VOB Yes ___ No ___
ZOT Yes ___ No ___
JIS Yes ___ No ___
CER Yes ___ No ___
DYL Yes ___ No ___
DOB Yes ___ No ___
WAM Yes ___ No ___
RUN Yes ___ No ___
QIC Yes ___ No ___
NYJ Yes ___ No ___
SIJ Yes ___ No ___
TUS Yes ___ No ___
LOD Yes ___ No ___
LIR Yes ___ No ___

TER Yes ___ No ___
GAN Yes ___ No ___
REP Yes ___ No ___
WOL Yes ___ No ___
JAZ Yes ___ No ___
HUK Yes ___ No ___
TYJ Yes ___ No ___
PYM Yes ___ No ___
FYT Yes ___ No ___
MOV Yes ___ No ___
BYG Yes ___ No ___
NEZ Yes ___ No ___
FEP Yes ___ No ___
MIV Yes ___ No ___
XIJ Yes ___ No ___
CYL Yes ___ No ___
GYN Yes ___ No ___
LAV Yes ___ No ___
QAP Yes ___ No ___
QAM Yes ___ No ___
KUS Yes ___ No ___
XIM Yes ___ No ___
TAZ Yes ___ No ___
VUR Yes ___ No ___
KYT Yes ___ No ___

CVC-100
Order 1 (cont.)

KIG Yes ___ No ___
ROS Yes ___ No ___
DAQ Yes ___ No ___
YUD Yes ___ No ___
LOF Yes ___ No ___
HYZ Yes ___ No ___
WUB Yes ___ No ___
MUF Yes ___ No ___
LUN Yes ___ No ___
SUF Yes ___ No ___
NEM Yes ___ No ___
PAG Yes ___ No ___
COF Yes ___ No ___
HIK Yes ___ No ___
XEG Yes ___ No ___
HOM Yes ___ No ___
MEN Yes ___ No ___
TYC Yes ___ No ___
FIP Yes ___ No ___
TUR Yes ___ No ___
XEC Yes ___ No ___
PEK Yes ___ No ___
ZUP Yes ___ No ___
DOR Yes ___ No ___
TYV Yes ___ No ___

SAF Yes ___ No ___
BIF Yes ___ No ___
WOJ Yes ___ No ___
NEV Yes ___ No ___
LYX Yes ___ No ___
PIL Yes ___ No ___
KOS Yes ___ No ___
XYH Yes ___ No ___
PEB Yes ___ No ___
HEX Yes ___ No ___
NAY Yes ___ No ___
YAT Yes ___ No ___
XYV Yes ___ No ___
KEB Yes ___ No ___
REB Yes ___ No ___
GEC Yes ___ No ___
HEJ Yes ___ No ___
WYK Yes ___ No ___
YUM Yes ___ No ___
VAF Yes ___ No ___
PEX Yes ___ No ___
QAZ Yes ___ No ___
TAL Yes ___ No ___
QYM Yes ___ No ___
GON Yes ___ No ___

CVC-100
Order 2

DYJ Yes ___ No ___
HYN Yes ___ No ___
PES Yes ___ No ___
JID Yes ___ No ___
NAB Yes ___ No ___
VOB Yes ___ No ___
JIS Yes ___ No ___
DYL Yes ___ No ___
WAM Yes ___ No ___
QIC Yes ___ No ___
SIJ Yes ___ No ___
LOD Yes ___ No ___
TER Yes ___ No ___
REP Yes ___ No ___
JAZ Yes ___ No ___
TYJ Yes ___ No ___
FYT Yes ___ No ___
BYG Yes ___ No ___
FEP Yes ___ No ___
XIJ Yes ___ No ___
GYN Yes ___ No ___
QAP Yes ___ No ___
KUS Yes ___ No ___
TAZ Yes ___ No ___
KYT Yes ___ No ___

ROS Yes ___ No ___
YUD Yes ___ No ___
HYZ Yes ___ No ___
MUF Yes ___ No ___
SUF Yes ___ No ___
PAG Yes ___ No ___
HIK Yes ___ No ___
HOM Yes ___ No ___
TYC Yes ___ No ___
TUR Yes ___ No ___
PEK Yes ___ No ___
DOR Yes ___ No ___
SAF Yes ___ No ___
WOJ Yes ___ No ___
LYX Yes ___ No ___
KOS Yes ___ No ___
PEB Yes ___ No ___
NAY Yes ___ No ___
XYV Yes ___ No ___
REB Yes ___ No ___
HEJ Yes ___ No ___
YUM Yes ___ No ___
PEX Yes ___ No ___
TAL Yes ___ No ___
GON Yes ___ No ___

CVC-100
Order 2 (cont.)

KUL Yes ___ No ___
SYB Yes ___ No ___
KEZ Yes ___ No ___
QYH Yes ___ No ___
QOJ Yes ___ No ___
CUX Yes ___ No ___
ZOT Yes ___ No ___
CER Yes ___ No ___
DOB Yes ___ No ___
RUN Yes ___ No ___
NYJ Yes ___ No ___
TUS Yes ___ No ___
LIR Yes ___ No ___
GAN Yes ___ No ___
WOL Yes ___ No ___
HUK Yes ___ No ___
PYM Yes ___ No ___
MOV Yes ___ No ___
NEZ Yes ___ No ___
MIV Yes ___ No ___
CYL Yes ___ No ___
LAV Yes ___ No ___
QAM Yes ___ No ___
XIM Yes ___ No ___
VUR Yes ___ No ___

KIG Yes ___ No ___
DAQ Yes ___ No ___
LOF Yes ___ No ___
WUB Yes ___ No ___
LUN Yes ___ No ___
NEM Yes ___ No ___
COF Yes ___ No ___
XEG Yes ___ No ___
MEN Yes ___ No ___
FIP Yes ___ No ___
XEC Yes ___ No ___
ZUP Yes ___ No ___
TYV Yes ___ No ___
BIF Yes ___ No ___
NEV Yes ___ No ___
PIL Yes ___ No ___
XYH Yes ___ No ___
HEX Yes ___ No ___
YAT Yes ___ No ___
KEB Yes ___ No ___
GEC Yes ___ No ___
WYK Yes ___ No ___
VAF Yes ___ No ___
QAZ Yes ___ No ___
QYM Yes ___ No ___

CCC-CVC
Form H
Order 1

JMP Yes ___ No ___

TWN Yes ___ No ___

DNT Yes ___ No ___

NCK Yes ___ No ___

ZNG Yes ___ No ___

FNK Yes ___ No ___

CFN Yes ___ No ___

WRZ Yes ___ No ___

GQC Yes ___ No ___

KBF Yes ___ No ___

RGW Yes ___ No ___

PTL Yes ___ No ___

BMG Yes ___ No ___

LFT Yes ___ No ___

THZ Yes ___ No ___

DWB Yes ___ No ___

KNG Yes ___ No ___

HPR Yes ___ No ___

SLW Yes ___ No ___

NQS Yes ___ No ___

HNW Yes ___ No ___

PZK Yes ___ No ___

BLP Yes ___ No ___

TCJ Yes ___ No ___

SJQ Yes ___ No ___

WOL Yes ___ No ___

WAM Yes ___ No ___

GEC Yes ___ No ___

KOS Yes ___ No ___

YUD Yes ___ No ___

QOJ Yes ___ No ___

MEN Yes ___ No ___

REB Yes ___ No ___

WYK Yes ___ No ___

XEG Yes ___ No ___

SIJ Yes ___ No ___

VAF Yes ___ No ___

CER Yes ___ No ___

QIC Yes ___ No ___

DYL Yes ___ No ___

NAB Yes ___ No ___

DOR Yes ___ No ___

DOB Yes ___ No ___

FIP Yes ___ No ___

JIS Yes ___ No ___

KEB Yes ___ No ___

HUK Yes ___ No ___

DAQ Yes ___ No ___

ZOT Yes ___ No ___

MUF Yes ___ No ___

CCC-CVC
Form H
Order 2

WOL Yes ___ No ___

WAM Yes ___ No ___

GEC Yes ___ No ___

KOS Yes ___ No ___

YUD Yes ___ No ___

QOJ Yes ___ No ___

MEN Yes ___ No ___

REB Yes ___ No ___

WYK Yes ___ No ___

XEG Yes ___ No ___

SIJ Yes ___ No ___

VAF Yes ___ No ___

CER Yes ___ No ___

QIC Yes ___ No ___

DYL Yes ___ No ___

NAB Yes ___ No ___

DOR Yes ___ No ___

DOB Yes ___ No ___

FIP Yes ___ No ___

JIS Yes ___ No ___

KEB Yes ___ No ___

HUK Yes ___ No ___

DAQ Yes ___ No ___

ZOT Yes ___ No ___

MUF Yes ___ No ___

JMP Yes ___ No ___

TWN Yes ___ No ___

DNT Yes ___ No ___

NCK Yes ___ No ___

ZNG Yes ___ No ___

FNK Yes ___ No ___

CFN Yes ___ No ___

WRZ Yes ___ No ___

GQC Yes ___ No ___

KBF Yes ___ No ___

RGW Yes ___ No ___

PTL Yes ___ No ___

BMG Yes ___ No ___

LFT Yes ___ No ___

THZ Yes ___ No ___

DWB Yes ___ No ___

KNG Yes ___ No ___

HPR Yes ___ No ___

SLW Yes ___ No ___

NQS Yes ___ No ___

HNW Yes ___ No ___

PZK Yes ___ No ___

BLP Yes ___ No ___

TCJ Yes ___ No ___

SJQ Yes ___ No ___

CCC-CVC
Form H
Order 3

TWN Yes ___ No ___
JMP Yes ___ No ___
DNT Yes ___ No ___
ZNG Yes ___ No ___
CFN Yes ___ No ___
GQC Yes ___ No ___
RGW Yes ___ No ___
BMG Yes ___ No ___
THZ Yes ___ No ___
KNG Yes ___ No ___
SLW Yes ___ No ___
HNW Yes ___ No ___
BLP Yes ___ No ___
SJQ Yes ___ No ___
NCK Yes ___ No ___
FNK Yes ___ No ___
WRZ Yes ___ No ___
KBF Yes ___ No ___
PTL Yes ___ No ___
LFT Yes ___ No ___
DWB Yes ___ No ___
HPR Yes ___ No ___
NQS Yes ___ No ___
PZK Yes ___ No ___
TCJ Yes ___ No ___

WOL Yes ___ No ___
GEC Yes ___ No ___
YUD Yes ___ No ___
MEN Yes ___ No ___
WYK Yes ___ No ___
SIJ Yes ___ No ___
CER Yes ___ No ___
DYL Yes ___ No ___
DOR Yes ___ No ___
FIP Yes ___ No ___
KEB Yes ___ No ___
DAQ Yes ___ No ___
MUF Yes ___ No ___
WAM Yes ___ No ___
KOS Yes ___ No ___
QOJ Yes ___ No ___
REB Yes ___ No ___
XEG Yes ___ No ___
VAF Yes ___ No ___
QIC Yes ___ No ___
NAB Yes ___ No ___
DOB Yes ___ No ___
JIS Yes ___ No ___
HUK Yes ___ No ___
ZOT Yes ___ No ___

CCC-CVC
Form H
Order 4

WOL Yes ___ No ___
GEC Yes ___ No ___
YUD Yes ___ No ___
MEN Yes ___ No ___
WYK Yes ___ No ___
SIJ Yes ___ No ___
CER Yes ___ No ___
DYL Yes ___ No ___
DOR Yes ___ No ___
FIP Yes ___ No ___
KEB Yes ___ No ___
DAQ Yes ___ No ___
MUF Yes ___ No ___
WAM Yes ___ No ___
KOS Yes ___ No ___
QOJ Yes ___ No ___
REB Yes ___ No ___
XEG Yes ___ No ___
VAF Yes ___ No ___
QIC Yes ___ No ___
NAB Yes ___ No ___
DOB Yes ___ No ___
JIS Yes ___ No ___
HUK Yes ___ No ___
ZOT Yes ___ No ___

TWN Yes ___ No ___
JMP Yes ___ No ___
DNT Yes ___ No ___
ZNG Yes ___ No ___
CFN Yes ___ No ___
GQC Yes ___ No ___
RGW Yes ___ No ___
BMG Yes ___ No ___
THZ Yes ___ No ___
KNG Yes ___ No ___
SLW Yes ___ No ___
HNW Yes ___ No ___
BLP Yes ___ No ___
SJQ Yes ___ No ___
NCK Yes ___ No ___
FNK Yes ___ No ___
WRZ Yes ___ No ___
KBF Yes ___ No ___
PTL Yes ___ No ___
LFT Yes ___ No ___
DWB Yes ___ No ___
HPR Yes ___ No ___
NQS Yes ___ No ___
PZK Yes ___ No ___
TCJ Yes ___ No ___

CCC-CVC
Form A

JMP Yes ___ No ___

WOL Yes ___ No ___

TWN Yes ___ No ___

WAM Yes ___ No ___

DNT Yes ___ No ___

GEC Yes ___ No ___

NCK Yes ___ No ___

KOS Yes ___ No ___

ZNG Yes ___ No ___

YUD Yes ___ No ___

FNK Yes ___ No ___

QOJ Yes ___ No ___

CFN Yes ___ No ___

MEN Yes ___ No ___

WRZ Yes ___ No ___

REB Yes ___ No ___

GQC Yes ___ No ___

WYK Yes ___ No ___

KBF Yes ___ No ___

XEG Yes ___ No ___

RGW Yes ___ No ___

SIJ Yes ___ No ___

PTL Yes ___ No ___

VAF Yes ___ No ___

BMG Yes ___ No ___

CER Yes ___ No ___

LFT Yes ___ No ___

QIC Yes ___ No ___

THZ Yes ___ No ___

DYL Yes ___ No ___

DWB Yes ___ No ___

NAB Yes ___ No ___

KNG Yes ___ No ___

DOR Yes ___ No ___

HPR Yes ___ No ___

DOB Yes ___ No ___

SLW Yes ___ No ___

FIP Yes ___ No ___

NQS Yes ___ No ___

JIS Yes ___ No ___

HNW Yes ___ No ___

KEB Yes ___ No ___

PZK Yes ___ No ___

HUK Yes ___ No ___

BLP Yes ___ No ___

DAQ Yes ___ No ___

TCJ Yes ___ No ___

ZOT Yes ___ No ___

SJQ Yes ___ No ___

MUF Yes ___ No ___

CCC-CVC
Form R

XEG Yes ___ No ___

TWN Yes ___ No ___

KBF Yes ___ No ___

WYK Yes ___ No ___

GQC Yes ___ No ___

DOR Yes ___ No ___

FIP Yes ___ No ___

YUD Yes ___ No ___

WRZ Yes ___ No ___

HUK Yes ___ No ___

DAQ Yes ___ No ___

DNT Yes ___ No ___

HNW Yes ___ No ___

DWB Yes ___ No ___

CFN Yes ___ No ___

JIS Yes ___ No ___

KOS Yes ___ No ___

ZOT Yes ___ No ___

BLP Yes ___ No ___

NCK Yes ___ No ___

SJQ Yes ___ No ___

LFT Yes ___ No ___

BMG Yes ___ No ___

DYL Yes ___ No ___

MEN Yes ___ No ___

ZNG Yes ___ No ___

GEC Yes ___ No ___

THZ Yes ___ No ___

QIC Yes ___ No ___

WAM Yes ___ No ___

PZK Yes ___ No ___

TCJ Yes ___ No ___

PTL Yes ___ No ___

REB Yes ___ No ___

SIJ Yes ___ No ___

QOJ Yes ___ No ___

NAB Yes ___ No ___

DOB Yes ___ No ___

CER Yes ___ No ___

KNG Yes ___ No ___

JMP Yes ___ No ___

RGW Yes ___ No ___

HPR Yes ___ No ___

NQS Yes ___ No ___

KEB Yes ___ No ___

VAF Yes ___ No ___

SLW Yes ___ No ___

FNK Yes ___ No ___

WOL Yes ___ No ___

MUF Yes ___ No ___

CVC-U
Order 1

KUL Yes ___ No ___
PES Yes ___ No ___
NAB Yes ___ No ___
CER Yes ___ No ___
DYL Yes ___ No ___
DOB Yes ___ No ___
WAM Yes ___ No ___
RUN Yes ___ No ___
TUS Yes ___ No ___
LOD Yes ___ No ___
LIR Yes ___ No ___
TER Yes ___ No ___
GAN Yes ___ No ___
REP Yes ___ No ___
WOL Yes ___ No ___
JAZ Yes ___ No ___
HUK Yes ___ No ___
FYT Yes ___ No ___
MOV Yes ___ No ___
CYL Yes ___ No ___
GYN Yes ___ No ___
LAV Yes ___ No ___
KUS Yes ___ No ___
KYT Yes ___ No ___
ROS Yes ___ No ___

LOF Yes ___ No ___
MUF Yes ___ No ___
LUN Yes ___ No ___
SUF Yes ___ No ___
PAG Yes ___ No ___
COF Yes ___ No ___
HIK Yes ___ No ___
HOM Yes ___ No ___
MEN Yes ___ No ___
TYC Yes ___ No ___
TUR Yes ___ No ___
PEK Yes ___ No ___
DOR Yes ___ No ___
SAF Yes ___ No ___
BIF Yes ___ No ___
NEV Yes ___ No ___
PIL Yes ___ No ___
KOS Yes ___ No ___
PEB Yes ___ No ___
HEX Yes ___ No ___
NAY Yes ___ No ___
REB Yes ___ No ___
YUM Yes ___ No ___
TAL Yes ___ No ___
GON Yes ___ No ___

CVC-U
Order 2

LOF Yes ___ No ___

LUN Yes ___ No ___

COF Yes ___ No ___

MEN Yes ___ No ___

BIF Yes ___ No ___

NEV Yes ___ No ___

PIL Yes ___ No ___

HEX Yes ___ No ___

KUL Yes ___ No ___

CER Yes ___ No ___

DOB Yes ___ No ___

RUN Yes ___ No ___

TUS Yes ___ No ___

LIR Yes ___ No ___

GAN Yes ___ No ___

WOL Yes ___ No ___

HUK Yes ___ No ___

MOV Yes ___ No ___

CYL Yes ___ No ___

LAV Yes ___ No ___

ROS Yes ___ No ___

MUF Yes ___ No ___

SUF Yes ___ No ___

PAG Yes ___ No ___

HIK Yes ___ No ___

HOM Yes ___ No ___

TYC Yes ___ No ___

TUR Yes ___ No ___

PEK Yes ___ No ___

DOR Yes ___ No ___

SAF Yes ___ No ___

KOS Yes ___ No ___

PEB Yes ___ No ___

NAY Yes ___ No ___

REB Yes ___ No ___

YUM Yes ___ No ___

TAL Yes ___ No ___

GON Yes ___ No ___

PES Yes ___ No ___

NAB Yes ___ No ___

DYL Yes ___ No ___

WAM Yes ___ No ___

LOD Yes ___ No ___

TER Yes ___ No ___

REP Yes ___ No ___

JAZ Yes ___ No ___

FYT Yes ___ No ___

GYN Yes ___ No ___

KUS Yes ___ No ___

KYT Yes ___ No ___

CVC-L
Order 1

DYJ Yes ___ No ___

SYB Yes ___ No ___

HYN Yes ___ No ___

KEZ Yes ___ No ___

QYH Yes ___ No ___

JID Yes ___ No ___

QOJ Yes ___ No ___

CUX Yes ___ No ___

VOB Yes ___ No ___

ZOT Yes ___ No ___

JIS Yes ___ No ___

QIC Yes ___ No ___

NYJ Yes ___ No ___

SIJ Yes ___ No ___

TYJ Yes ___ No ___

PYM Yes ___ No ___

BYG Yes ___ No ___

NEZ Yes ___ No ___

FEP Yes ___ No ___

MIV Yes ___ No ___

XIJ Yes ___ No ___

QAP Yes ___ No ___

QAM Yes ___ No ___

XIM Yes ___ No ___

TAZ Yes ___ No ___

VUR Yes ___ No ___

KIG Yes ___ No ___

DAQ Yes ___ No ___

YUD Yes ___ No ___

HYZ Yes ___ No ___

WUB Yes ___ No ___

NEM Yes ___ No ___

XEG Yes ___ No ___

FIP Yes ___ No ___

XEC Yes ___ No ___

ZUP Yes ___ No ___

TYV Yes ___ No ___

WOJ Yes ___ No ___

LYX Yes ___ No ___

XYH Yes ___ No ___

YAT Yes ___ No ___

XYV Yes ___ No ___

KEB Yes ___ No ___

GEC Yes ___ No ___

HEJ Yes ___ No ___

WYK Yes ___ No ___

VAF Yes ___ No ___

PEX Yes ___ No ___

QAZ Yes ___ No ___

QYM Yes ___ No ___

CVC-L
Order 2

KIG Yes ___ No ___

DAQ Yes ___ No ___

WUB Yes ___ No ___

NEM Yes ___ No ___

XEG Yes ___ No ___

FIP Yes ___ No ___

XEC Yes ___ No ___

ZUP Yes ___ No ___

TYV Yes ___ No ___

XYH Yes ___ No ___

YAT Yes ___ No ___

KEB Yes ___ No ___

GEC Yes ___ No ___

WYK Yes ___ No ___

VAF Yes ___ No ___

QAZ Yes ___ No ___

QYM Yes ___ No ___

SYB Yes ___ No ___

KEZ Yes ___ No ___

QYH Yes ___ No ___

QOJ Yes ___ No ___

CUX Yes ___ No ___

ZOT Yes ___ No ___

NYJ Yes ___ No ___

PYM Yes ___ No ___

NEZ Yes ___ No ___

MIV Yes ___ No ___

QAM Yes ___ No ___

XIM Yes ___ No ___

VUR Yes ___ No ___

YUD Yes ___ No ___

HYZ Yes ___ No ___

WOJ Yes ___ No ___

LYX Yes ___ No ___

XYV Yes ___ No ___

HEJ Yes ___ No ___

PEX Yes ___ No ___

DYJ Yes ___ No ___

HYN Yes ___ No ___

JID Yes ___ No ___

VOB Yes ___ No ___

JIS Yes ___ No ___

QIC Yes ___ No ___

SIJ Yes ___ No ___

TYJ Yes ___ No ___

BYG Yes ___ No ___

FEP Yes ___ No ___

XIJ Yes ___ No ___

QAP Yes ___ No ___

TAZ Yes ___ No ___